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BIDS FOR THE ARMORED CRUISERS "Tennessee" and "Washington" were received on Jan. 6, as noted in our Construction News Supplement this week. The ships for which bids were opened are to be first-class armored cruisers, and were authorized by act of Congress, approved July 1, 1902. The cost of each is not to exceed $4,650,000. Forty-two months is allowed for construction, and a minimum speed trial of 21½ knots is required. Each cruiser will measure on load water line 502 ft. in length and 72 ft. 10½ ins. at extreme breadth. They will have a trial displacement of not more than 14,500 tons each, a total coal bunker capacity of about 2,000 tons and a mean draft at trial displacement of 25 ft. The hulls are to be of steel throughout. The armament of each will consist of a main battery of four 10-in. and 16 6-in. breech-loading rifles, and 22 3-in. rapid-fire guns, and a secondary battery of 12 3-pdr. semi-automatic rapid-fire guns, two 1-pdr. automatic guns, two 1-pdr. rapid-fire guns, two 0.30 caliber Gatling guns, six 0.30 caliber Colt automatic guns and two 3-in. field guns. The hulls will be protected by a water line belt of armor worked in vertical strakes amidships, where it will be about 18 ft. in height. The armor will be of a uniform thickness of 5 ins. throughout the machinery and magazine spaces, and 3 ins. forward and aft of this. The protective deck will extend from stem to stern, being flat amidships, but sloping at the sides and at each end. It will be built up of 20-lb. lower plating throughout, with nickel steel of 40 lbs. on the flat and 140 lbs. on the slopes. Hoists driven by an electric motor and delivering seven pieces a minute will convey the ammunition for 6-in. and smaller guns directly from the ammunition rooms to the deck where it is required. The turret guns will have regular ammunition hoists operated by electric power leading directly from the handling room to the turrets. The ships will be propelled by vertical twin-screw, four-cylinder, triple-expansion engines of a combined horse-power of not less than 23,000. There will be 16 boilers of the straight-water-tube type on each cruiser, placed in eight water-tight compartments. These will furnish steam for the main engines, and all the necessary auxiliary and other machinery throughout the ship. Each cruiser will be fitted with four funnels, 100 ft. high above the base line. The vessels will be lighted throughout with electricity. With the exception of certain auxiliaries to be operated by steam, all power on board will be electric, including foot cranes, turret-turning motors, ventilation, fan motors, etc. A feature of the bids was the submission of a proposition for propelling the vessels by steam turbines.

BIDS FOR SLOW SAND FILTERS, pure water reservoir and appurtenances, and Portland cement for the water supply of the District of Columbia are to be received at Washington until Jan. 28, 1903, by Lieut.-Col. A. M. Miller, 2728 Pennsylvania Ave. There will be 24 and perhaps 29 filter beds, with net areas of about one acre each, involving the construction of earth embankments and concrete walls, floors and roofs.

SPECIFICATIONS FOR CLEARING THE BASIN to be flooded by the New Croton Dam have been prepared by Mr. W. R. Hill, Chief Engineer of the Croton Aqueduct Commission.

TREE CUTTING IN THE CROTON DRAINAGE AREA of the New York water supply, to which subject the New York "Tribune" recently devoted nearly a column of its editorial space, turns out on investigation to be confined to neglected growth, mostly or wholly underbrush, within 200 ft. of the water line of the streams and reservoirs, and stub timber in swamp lands. In addition to the cutting in the swamp lands, drainage work is in progress there. It may be added that a systematic effort is being made by the water and health departments to raise the standard of the Croton water supply in all possible ways, to which end a joint sanitary survey of the drainage area is being made. It is hoped that trimming up the banks of the streams and reservoirs will aid in diminishing the amount of decaying vegetable matter in the water, thus reducing the tastes and odors that occasionally prevail, and that the swamp work will have the same effect, and, in addition, will reduce the color of the water. Mr. Nicholas Hill, Jr., is Chief Engineer of the Department of Water Supply, Gas and Electricity; Mr. Geo. C. Whipple, Assoc. M. Am. Soc. C. E., is coöperating in the bacteriological studies; and Dr. Ernest J. Lederle is Commissioner of Health.

AN INTERNATIONAL EXPOSITION OF HYGIENE at Buenos Ayres, Argentine Republic, is to be held in April, 1904, in connection with the second Latin-American Medical Congress.

THE INTERNATIONAL CONGRESS of Hygiene and Demography will be held at Brussels, Belgium, Sept. 2 to 8, 1903. This congress is held once in three years for the discussion of the wide range of subjects included under hygiene and demography. Further information may be secured by addressing the Central Committee at Brussels.

THE ELECTRIC PUMPING PLANT at the Bridgeport pumping station, Chicago, for supplying the Illinois & Michigan canal with water from the Chicago River for navigation and power purposes, was put in operation Dec. 31. The plant was installed last year, and the pumps have been operated by steam for some months. Two 300-HP. General Electric induction motors are belted to pulleys on opposite ends of a line shaft, from which five Connersville rotary pumps are driven by belts. Each pump has a capacity of 6,600 cu. ft. per minute, and discharges through a siphon which acts as an air chamber. A long distance transmission line brings a current of 30,000 volts from the water power plant of the Economy Light & Power Co., at Joliet, 35 miles away, and this is transformed to a 2,300-volt current at the pumping station. The plant is owned and operated by the Illinois Canal Commissioners, and was designed by Mr. Thomas T. Johnston, Consulting Engineer, of Chicago.

FOUR ROTARY CONVERTERS of 2,000-KW. capacity each, said to be the largest ever constructed, are to be furnished to the New York Light, Heat & Power Co. by the Stanley Electric Manufacturing Co. for erection in substations.

A LARGE PAPER MILL, to be driven by alternating-current induction motors, is being built by the Sturgeon Falls Pulp Co., of Ontario, Canada, Mr. Geo. F. Hardy, Engineer. The machinery, which is of Westinghouse manufacture, includes three Type C 75-HP. motors and a number of smaller machines. Current is furnished by a 500-KW. revolving field alternator direct-connected to a water-wheel.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the collision of a light engine with a passenger train on the Rutland R. R. near Burlington, Vt., on Jan. 2. Four men, the engineer and fireman of both engines, were killed in the wreck, and several other trainmen were hurt. The light engine was an extra and was being hurried up the road while the passenger train was about due, the collision being probably caused by a miscalculation of the engine's clear time.—In addition to the two Grand Trunk Ry. accidents reported in this column in our last issue, we have to note another fatal wreck which occurred on the same road on Jan. 3. An eastbound express train and a light engine, westbound, met in a head collision near St. Catherine's, Ont., killing two men of the engine crews. The blame for the collision is placed on the driver of the light engine, who is said to have not followed his running orders. It will be remembered that the two accidents of the previous week on this same road were also butting collisions, one case being very similar to the present accident, while the other resulted from an error in train dispatching.

RAMMING A DYNAMITE BOX with a crowbar to open it caused the death of three Polish miners and the serious injury of at least ten others from the explosion that followed the ramming. The accident occurred Jan. 1, at the Oak Hill Colliery at Minersville, Pa. The three miners killed were blown to atoms by the 100 sticks of giant in the box; and the blocking up of gangways with debris for a time prevented the rescue of the injured.

A CAVE-IN OVER A MINE at Olyphant, Pa., on Jan. 2, destroyed part of the town. The buildings over an area of two blocks are reported to have settled at least 30 ft. It was at first rumored that 100 miners had been entombed, but as the cave-in was over abandoned working no lives are reported lost. Many of the wrecked buildings were destroyed by fires from overturned stoves. The Eddy Creek Mine (coal) where the cave-in occurred has been partly flooded by water from the Lackawanna River that entered through fissures developed by the earth subsidence.

THE FUEL OIL EXPLOSION on the steamer "Progreso" in San Francisco that caused such loss of life a few weeks ago, has been reported upon by the U. S. Inspectors of Hulls and Boilers. They fix the responsibility for the explosion primarily upon the Union Oil Co., which furnished an oil that flashed at 85 to 101° F., or 9 to 25° F. below the standard set in the city ordinances. The direct cause of the explosion was either the careless handling of red hot rivets or lights near the oil tanks, or perhaps some defect in electric wiring.

THE BURSTING OF AN ELECTRIC TURBINE at the Yale and Towne works, Stamford, Conn., occurred Jan. 3. The dynamo had been making 3,600 revs. per min. for 10 mins. when the accident occurred. Fragments weighing 200 to 300 lbs. were hurled about the room, but no one was injured, although eight men were in the room.

BITUMINOUS MINERS WILL DEMAND a wage increase of 15 to 20% the latter part of this month, it is said. Their annual convention will be held Jan. 19, at Indianapolis.

THE LARGEST GOLD CYANIDE MILL in the United States is building at the Mague Mine, Lawrence county, S. D., with a daily capacity of more than 1,000 tons.

NEW GOLD DISCOVERIES IN ALASKA are reported to have been made: one a rich placer field on Arizona Creek, 100 miles up the Klondike River; another, a gold quartz ledge on the head waters of Chicken Creek, Forty-Mile district. In Atlin District a dozen large hydraulic plants are on the ground ready for operation in the spring. This marks the beginning of a new era in Alaska placer mining.

THE ALASKAN RAILWAY, from Valdes to Eagle and thence to Dawson, known as the Valdes, Copper River and Yukon Railway, is to be built by J. B. McDonald, of New York, present contractor for the Rapid Transit Subway. The length of the road is 500 miles, and the time limit is three years, but the section to Copper River must be finished this year. The cost will be about $10,000 a mile, and 5,000 men will be sent to Alaska next spring to start the work. The first shipment of rails is ready and orders for the rest have been placed in Pennsylvania and Europe. It is predicted that a million people will settle in Copper River Valley within a few years.

THE GOLD PRODUCT OF THE BLACK HILLS, S. D., for 1902 was $8,373,392, or nearly 12% increase over 1901. Of this the Homestake Mine produced over half. The ore milled during the year averaged $4.44 per ton for the 1,860,944 tons treated. There are now 3,207 men employed in the mines and mills, at union wages. Six new cyanide plants, with a monthy tonnage capacity of 51,300, are building; and it is predicted in consequence that the year of 1903 will show a gold output from this district of $12,000,000.

RAPID BRIDGE ERECTION IN CHICAGO.

Some rapid work has recently been done at Chicago in the erection of the bascule bridges over the Calumet River at 95th St., and over the Chicago River at Division St. Both of these bridges are of the fixed trunnion type of bascule, and the 95th St. bridge was described and illustrated in our issues of Jan 10 and 31, 1901. Both bridges were erected with the leaves standing in an almost vertical position.

The 95th St. bridge has a span of 154 ft. c. to c. of trunnions, and the height from the water line to the top of the leaf when raised is about 110 ft. The leaf on the east side of the river was erected in 36 working hours, with a force of 18 to 20 men. This includes the hoisting, assembling and service bolting, but does not include the riveting. The weight of metal thus erected was about 200 tons. In the lower part of the work a stiff-leg derrick with 40-ft. mast and 65-ft. boom was used. For the upper part of the work, the boom was lengthened by splicing on another timber, making the exceptional length of 102 ft. This is shown in the accompanying cut. Both sticks of the boom were 14 × 14 ins., and it was supported at several points by guys from the mast. This boom was used on two days, and care was taken to bring the material close to the derrick so as to have as little horizontal sweep as possible. The maximum loads handled by this exceptionally long boom were about 3 tons.

An interesting feature of the work was the use of electric power for the derrick and air compressor, as well as for the pile driver used on the substructure, as noted in our issue of June 26, 1902. The derrick was operated by a 25-HP. motor. All drilling and riveting in erection was done by pneumatic tools, 7 riveting hammers and 2 drills being used, but these were not all in use at one time. To supply the air for these tools, an air compressor with a capacity of 100 cu. ft. of free air per minute was installed, and belted to a 20-HP. motor. The working pressure is about 100 lbs. per sq. in. in the receiver, but when the pressure exceeds 110 lbs. or falls below 100 lbs. an automatic cut-off shuts off both the compressor and the motor. This effects a decided economy in cost of operation and cost for current. In fact, the charge for one month's work with this machine was $16, as compared with $240 for coal for a steam driven air compressor at the Division St. bridge. In addition to this, the latter required the continual attention of an engineman at $5 a day.

DERRICK WITH BOOM 102 FT. LONG, USED IN THE ERECTION OF THE 95TH ST. BRIDGE OVER THE CALUMET RIVER, CHICAGO. Roemheld & Gallery, Chicago, Contractors.

The Division St. bridge is of the same type, but only 146 ft. span c. to c. of trunnions. In erecting the bridge, a trussed timber boom 113 ft. long was used. This was built up of 3-in. pine timbers, with three sets of transverse struts of X-form, carrying ⅝-in. wire cables by which the boom was trussed. About the same weight of metal, 200 tons, was erected here in six days, but it was after the experience obtained on this bridge that the 36-hour record was made on the 95th St. bridge.

The contractors for the substructure and superstructure of both these bridges are Roemheld & Gallery, 719 Chamber of Commerce Building, Chicago, to whom we are indebted for information and photographs respecting the work.

MODERN TURBINE PRACTICE AND WATER POWER DEVELOPMENT.*‡

II.

By John Wolf Thurso,† Civil and Hydraulic Engineer.

SPEED REGULATION IN WATER POWER PLANTS.

Perhaps the greatest difficulty encountered by the hydraulic power engineer, is the governing of turbines under variable loads.

As is well known to engineers, turbine gates cannot be actuated directly by the centrifugal governor, on account of the great power required for their movement, and an auxiliary machine, called a relay or servomotor, and controlled by the centrifugal governor, is therefore employed to actuate the gates and the governor is called, according to the form of power used in the relay, a mechanical, hydraulic or electrical governor.

Electrical governors, although used to some extent in Europe, have so far found little favor in America. Mechanical and hydraulic governors of good design both serve their purpose equally well, but the hydraulic governor is the simpler of the two, and therefore to be preferred.

It may be said here that the best American governors now on the market are very complicated, and that most European builders attain the same results by much simpler means. (See Figs. 36 to 39, Eng. News, Dec. 4.) For example, it may be stated that the hydraulic governors regulating the turbines at Jajce, Bosnia, already mentioned in this paper (see Figs. 15 to 17) keep the speed within 1½% of the normal, with variations in load of 10%, and within 5% of normal speed when the full load is suddenly thrown off. However, a small flywheel is used to aid the governor.

A hydraulic governor, shown at the Paris exhibition in 1900, by a Swiss firm, of this same design as shown in Figs. 31 to 33, keeps the speed of a turbine working under 1,312 ft. head, within 3% of the normal, when the full load of several hundred horse-power is suddenly thrown off, while the pressure in the penstock, which is 6,560 ft. long, only varies 10%. Both these governors are very simple and compact.

In some of the illustrations of governors (Eng. News, Dec. 4), reference letters are given, which have the following meanings: C is the centrifugal governor, M is the relay or servomotor, S is the valve gear or valve, and Z is the return action, to prevent over-governing or racing.

Mr. Allan V. Garratt, in a paper read before the American Institute of Electrical Engineers in 1899 and reprinted in Engineering News of July 27, 1899, states that with favorable conditions, the speed may be kept within 5 or 6% of the normal, when the full load is suddenly thrown off and it will require between five to fifteen seconds for the turbine to return to the normal speed. With ordinary electric railway loads, speed variations of about 3% as a maximum, may be expected These figures should be borne in mind, as there are several very poor governors now on the market, whose makers will always be ready to guarantee any limit of speed variation, without even going to the trouble to inform themselves about the arrangement of the plant to be regulated, while builders of high-class governors will usually not commit themselves by any definite guarantee.

The pressure water, for working the relay of a hyraulic governor, may be taken directly from the penstock, if the pressure in the latter is high enough. This water should be filtered or passed through a fine screen or strainer to prevent sand or other impurities of the water from reaching the working parts of the relay. Two strainers should be provided, so that one may be cleaned while the other is in use. Where the penstock pressure is too low and a pump and accumulator has to be employed to work the relay, a mineral oil is used instead of water.

Where turbines subject to great and sudden variations in load are supplied by long penstocks, and especially where such penstocks have great length in proportion to their head, even the greatest refinement in the governor cannot produce

*The first of these papers was published in Engineering News of Dec. 4.

†75 Common St., Montreal, P. Q.

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good regulation, as the governor is, of course, not capable of absorbing or supplying energy to the turbines.

The best means for improving the regulation in such cases is an open stand-pipe of large diameter, with its top slightly above the high-water level in the head race. Such a stand-pipe will prove the best possible relief valve, and when the gate opening of the turbines is quickly reduced it will let the water escape over its top edge until the water column in the penstock has slowed down. It will also, when the gate opening is suddenly enlarged, supply energy to the turbines until the speed of the water has increased to meet the demand, provided, of course, that the stand-pipe is made of sufficient capacity. Stand-pipes must be carefully protected from freezing, as otherwise they may be rendered entirely useless.

With high heads, stand-pipes would be very expensive and less effective withal, on account of the inertia of the water column in the stand-pipe. In such cases flywheels are extensively used in Europe, and to some extent in this country. Such flywheels store energy enough to retard the changes in speed of the turbine with changes of load. As the turbine runners themselves have very little momentum, the use of a flywheel will also eliminate the small variations in speed, due to slight but sudden fluctuations in load, to the surging of the water in the penstock and draft tube and to other causes, which momentary variations even the best governor cannot prevent. Where the turbines are used to drive dynamos sufficient flywheel capacity may be given to the armature or revolving field to make a separate flywheel unnecessary. This plan was adopted by the Niagara Falls Power Co. for its 5,000-HP. alternating machines.

Air chambers are often used on penstocks, but while they may be useful to protect the penstock against the effects of water hammer, they are of little or no value as an aid to the regulation of the turbines. To cushion the shocks in a penstock an air chamber should be of ample capacity, and as air is readily absorbed by the water, an air pump should be provided to replace the air thus carried off. Gage glasses and try-cocks should be placed on each air chamber, so that it may at once be seen whether it is effective.

Relief valves on penstocks are well known, but are usually of poor design, and will not open sufficiently. Where they are used provision should also be made for ascertaining at any time whether the valves are in working condition.

Stand-pipes and air chambers should be placed close to the lower end of the penstock or the turbine cases and connected to the same by necks or pipes of large diameter.

Where economy in water-consumption is of no object, a bypass-regulation can be recommended. With such regulation the flow in the penstock is at all times uniform and sufficient to run the turbines at their full capacity, but only so much water is run through the turbines as the load demands, the rest being run to waste. This method not only permits the closest speed regulation with violently fluctuating loads, but also relieves the penstock from shock or water hammer, and is therefore often used in connection with Pelton wheels working under high heads and supplied by very long penstocks.

What may be called a temporary bypass-regulation has been frequently used in Europe in recent years, and wastes little water compared with the ordinary method. The turbine gates and the bypass gate are connected by means of cataracts or dashpots. When the turbine gates are quickly closed the bypass is opened, but the bypass gate at once commences to close again, being actuated by springs, counterweights or hydraulic pressure. The time required to close the bypass is easily regulated by changing the size of the aperture connecting the two ends of the dashpots. Figs. 28 to 30 (Engineering News, Dec. 4) show a pair of impulse or action turbines, arranged with temporary bypass. On the right side of the front view, Fig. 28, is the dashpot, the piston of which forms the counterweight to close the bypass. While this arrangement gives full protection to the penstock and perfect regulation with a decreasing load, it, of course, cannot assist the governor to prevent slowing of the speed when the load on the turbine is increasing.

THROTTLING-GATES FOR SPEED REGULATION.

To regulate the speed of turbines by means of throttling the water, either in the penstock above or in the draft tube below the turbine, is, next to the bypass regulation, the most wasteful arrangement possible, as has already been stated in connection with the European practice, and this method should never be employed.

It was therefore a great surprise to the writer to find that the two large turbines installed in the main power-house of the Shawinigan Water & Power Co., at Shawinigan Falls, Que., and shown in Figs. 40 and 41 of the preceding article, are regulated in this manner, having two butterfly throttling-valves inside of the discharge opening of the draft tee or at the upper end of the draft tube, and as the plant is of considerable importance and the turbines are the most powerful that have been built up to the present time, it would be well here to consider the matter at some length.

According to the information kindly furnished by Mr. W. C. Johnson, chief engineer of the Shawinigan Water & Power Co., and by the J. P. Morris Co., of Philadelphia, Pa., the builders of the turbines, it may be stated that each unit consists of a pair of radial inward flow reaction turbines on horizontal shaft, and each pair of turbines is to develop 6,000 effective HP., under 125-ft. head, and at 180 revs. per minute, using 576 cu. ft. of water per second, and therefore having an efficiency of 73.6%, when working with full capacity, but this figure is very low for such a turbine, and an efficiency of about 78% will probably be obtained in practice. Taking here a mean of 75% as the efficiency of the turbines when developing their full power, we have:

Turbine working with full capacity and using 565 cu. ft. of water per second: Head 125 ft., effective horse-power 6,000, efficiency 75%.

Turbine using 75% of the water passed at full capacity, or 424 cu. ft.: Effective head 70.3 ft., head destroyed by throttling gates 54.7 ft., effective horse-power 2,160, efficiency corresponding to 125 ft. head 36%, while register or wicket gates would utilize the whole head of 125 ft. and give an efficiency of about 78%.

Turbine using 50% of the water passed at full capacity, or 283 cu. ft.: Effective head 31.25 ft., head destroyed by throttling gates 93.75 ft., effective horse-power zero, efficiency corresponding to 125 ft. head, zero, while register or wicket gates would utilize the whole head of 125 ft. and give an efficiency of about 72%.

At first sight it seems absurd that a turbine using one-half of the water that is required to give its full power should develop no power at all, but a few simple considerations will show this to be the case.

To begin with, it should be stated that the size of the passage area of the guide and runner buckets is not changed by the position of the throttling gates, and with half of the amount of water that is used at full load, flowing through the buckets, the speed of the water in the buckets will also be only one-half and the head corresponding to that velocity will be:

$$H = \frac{(0.5\ v)^2}{2\ g},$$

or one-quarter of the total head, the remaining three-quarters of the head must be destroyed by the throttling-gates. Of course, in practice, the head and the velocity will vary somewhat from the theoretical figures, but the results will be about the same.

It will, therefore, at once be seen that the throttling-gate regulates the speed of a turbine by artificially changing the effective head, and these changes can only be in a downward direction, or by decreasing the head, except the throttling-gate has been so arranged in the first place as to destroy a part of the head, when the turbine is working with its regular load.

As a matter of fact, the same efficiency as obtained by throttling-gates can be had by regulating the turbines by means of the head gates, or tailrace gates or by variable obstructions in the penstocks or draft tubes, which latter, in fact, throttling-gates are.

It will also be seen that the turbine, working under one-quarter of the total head, and with only one-half of the full amount of water, will give one-eighth of the full power, or, in this case, 750 HP., provided the turbine is allowed to run at the speed corresponding to one-quarter of the total head, that is, at one-half of its normal speed. However, when the speed of the turbine has to be kept normal, as required in almost every plant, especially when directly connected to an alternating dynamo, as in this instance, the water when flowing through the turbine at one-half its proper speed, will have no opportunity to do work in the turbine, but will drop freely through the runner buckets.

This may be better understood if it is remembered that a turbine, no matter whether of the reaction or free deviation type, gives the best efficiency, and is therefore always made to run at about one-half of the velocity due to the head, or, in other words, a turbine allowed to revolve freely will run with twice the velocity at which it gives the best efficiency, but the turbine can develop no power when running at the full speed due to the head, as the runner buckets move with the same velocity as the water and the water therefore can exert no pressure upon the runner buckets.

These considerations will show that a turbine having a constant passage area of the buckets and running with a constant speed, can develop no power when only one-half of the full amount of water flows through the turbine, as the velocity of the water will also be only one-half of the speed at full capacity or the speed of the turbine, remaining constant, will be twice as fast, relative to the water, and the runner buckets will have the same velocity as the water. This can be proved analytically or graphically by plotting the relative and absolute waterways.

Therefore it may be stated that the large turbines at Shawinigan Falls, Que., when running at normal speed, but without any load except their own friction and the friction of the dynamos, directly coupled to the turbines, will each require over 283 cu. ft. of water per second, or more than the amount required to develop 3,000 HP.

It is only fair to mention here that the guide and runner buckets of the turbines are divided by a third crown into two unequal parts, and ring or cylinder-gates, not shown in the figures, and worked by power, but controlled by hand, are provided outside of the guide wheels. With these ring-gates, the smaller part of the guide wheels can be closed and the turbine will then develop 4,500 HP., with practically full-gate efficiency, the arrangement being about the same as having two turbine units, the smaller one being shut down when the larger one alone is sufficient to carry the load, but the effect of the regulating or throttling-gates on the efficiency is the same, except that when the ring-gates are closed the throttling-gates are applied to a 4,500-HP. turbine.

With 125-ft. head and 75% efficiency of the whole plant the available power at Shawinigan, with average low water, is about 95,000 HP. when computed from the drainage area, and about 85,000 HP., according to accurate measurements made a few miles above Shawinigan, while the writer was chief engineer of construction for the Laurentide Pulp Co.'s plant, at Grand'Mère, Que. This power is considerably less than is usually asserted, and wasteful regulating-gates, therefore, seem hardly to be warranted.

However, this was not written for the sake of criticising the turbines employed at Shawinigan, but to warn young and inexperienced engineers against the use of throttling-gates, as they might be easily misled by seeing them used in such an important plant.

WATER RACKS.

Water racks will give reasonable safety against choking or damaging the turbines if the space between the bars is less than the least clear dimension of the water passages in the guide or runner buckets. Temporary choking may occur with the turbine gates nearly closed, but this can usually be relieved at once by opening the gates. This rule may be employed with the European type and small sizes of the American type of turbine, but the larger sizes of the latter give too great a spacing.

The following figures are considered as good practice:

Fine racks: Clear space between bars ¾ to 1½ ins., bars of wrought iron or steel, ¼ to ⅜-in. thick, by 3 to 4 ins. wide.

Coarse racks in front of fine racks: Clear space between bars 3 ins., bars of wrought iron or steel, ½ to ¾-in., or even 1 in. thick, by 4 to 5 ins. wide.

Instead of coarse racks, glance booms are mostly used now. They are cheaper, and if properly arranged require no labor to clear them of rubbish, but they do not stop rubbish floating under water. Cribs with water passages near the bottom, are an improvement over the boom and should be arranged for the use of stoplogs to shut out the water from behind the cribwork when desired.

PENSTOCKS.

Penstocks or feeder pipes should always be as short as possible, even when a shorter penstock involves a greater expenditure. This is for the reason that the shorter the penstock the better it is for the speed regulation of the turbines, and the less steel plate work has to be kept painted and repaired.

The following rules should be observed when determining the cross-sectional area of the conductors, which convey the water to and from the turbines:

The speed of the water should be gradually increased from the speed in the headrace, usually 2 or 3 ft. per second, to the penstock speed, by means of a cone or taper piece. Near the lower end of the penstock the speed should again be gradually increased, so that the water will arrive at the guide buckets with a speed equal to that with which it has to enter these guide buckets. At the entrance of the draft tube, or draft tube elbow or tee, the water should have a speed equal to the absolute velocity with which it quits the runner buckets, and should then gradually decrease to a speed of about 2 or 3 ft. at the lower end of the draft tube. A speed of 2 or 3 ft. is also usually chosen for the tailrace.

In general it may be advised to avoid changes of speed of the water where possible, but where such changes are necessary make them gradually, also, avoid changes of direction of water, but where such changes are necessary, use curves of long radius.

The arrangement often employed of having at the lower end of the penstock and at right angles to the same a drum or receiver of much larger diameter than the penstock itself, from which drum a number of turbines are supplied, by branches set at right angles to the drum, must be regarded as open to criticism on account of the abrupt changes in speed and direction of the water.

When fixing upon speeds for the water in the penstock all conditions should be carefully considered.

Conditions making a low speed advisable, are: Low head, large diameter of penstock, great length of penstock, many bends in penstock, variable loads on the turbines, regulation of speed of turbines by changing the amount of water used.

Conditions making a high speed permissible, are: High heads, small diameter of penstock, short penstock, few or no bends in penstock, steady loads on the turbines, regulation of speed of turbines by bypass.

Many mill engineers in the United States employ in all cases a penstock speed of 3 ft. per second, but it is often of advantage to greatly exceed this velocity. From a great number of well-designed water power plants constructed in America and Europe during recent years, the writer has deduced the following table of highest permissible speeds of water in penstocks of a length of 1,000 or less, with easy bends, and provided with the proper (or suitable) arrangement of relief-valves or air chambers, or both:

Diameter of penstock, in feet.....	4	6	8	10	12
Speed of water, feet per sec.....	12	11	10	9	8

In penstocks of 1 or 2 ft. diameter, speeds as high as 20 to 30 ft. have been used. With very low heads the penstock speed is often limited by the amount of head that it is permissible to lose in the penstock.

The principal losses in the head of the water while entering the penstock and flowing through the penstock and draft tube, are due to the following causes:

(1) The entrance loss: This loss may be kept low by having a large entrance connected to the penstock by an easy cone or taper piece. With the usual headgate arrangement such large entrance openings require very heavy and cumbersome gates for penstocks of large diameter, but there is no reason why this taper piece could not be partly or wholly in front of the gate and inside the headrace or forebay. The penstock entrance should always be as much below the surface of the water as circumstances will permit.

(2) The friction loss: This loss may be kept down by a low speed of water and by smooth interior of the penstock and draft tube.

(3) The loss due to changes in direction of flow: This loss may be kept down by using as few and as easy bends as possible.

(4) The loss caused by changes in speed of the water: This loss is due to the conversion of part of the energy in the water into another form, and may be kept low by having as few and as gradual changes as possible.

(5) The loss due to the speed of the water while leaving the lower end of the draft tube: This loss is equal to the velocity head, corresponding to the speed with which the water leaves the draft tube, and may be kept down by making this speed low.

Many engineers regard the velocity head corresponding to the speed of the water in the penstock, as a total loss, but it should be clearly understood that this is not the case.

Penstocks are usually made of tank steel, but for penstocks carrying water at high speeds shell plate steel should be used, having an ultimate strength of 55 to 65,000 lbs. per square inch and an elongation of 22% in 8 ins.

A factor of safety of 3 to 4 may be used for short penstocks of large diameter, carrying water at low speeds and supplying turbines with steady loads or regulated by means of a bypass. A factor of safety of 4 to 6 may be adopted for long penstocks of small diameter, carrying water at high speeds and supplying turbines with variable loads regulated by changing the amount of water used.

A penstock which is carried for a considerable distance at about the same elevation as that of its inlet and with so little slope as to be nearly horizontal, and then descends to the power house on a steep grade, is liable to collapse when the turbine gates are opened quickly, as the water in the inclined part has the tendency to increase its speed faster than the water in the horizontal part, and may thus break away from the latter and cause a vacuum in the penstock. An air inlet valve will prevent this, but it is better to have a small reservoir at the junction of the horizontal and inclined part of the penstock. Such a reservoir will not only prevent the collapse of the penstock from the cause above named, but will also greatly improve the regulation of the turbines and decrease the water hammer in the penstock, acting, in fact, in the same manner as a stand-pipe.

The writer would suggest here a safety arrangement for the lower end of long penstocks not provided with a stand-pipe and carrying water at high speed. The lower end of the penstock should be provided with a cast-iron or angle-bar flange to which the head, closing the lower end, is bolted. The flange bolts should have a factor of safety of not more than about half the factor employed for the rest of the penstock. Between flange and head a packing of dry white pine should be used which, when water is admitted to the penstock, swells and makes a tight joint. Where the end cannot be used for this purpose large nozzles may be riveted to the penstock, located as nearly as possible in the line of the water hammer and closed by heads secured as just described. The end of the penstock or the nozzles should be so situated that, should the heads blow out, no damage will be done by the jet of water issuing from the opening. This arrangement will not only save the penstock and turbines from being wrecked in case of severe water hammer, but also the power house from being demolished by the water set free.

Ample air inlets should be provided at the upper end of the penstock, as otherwise should the safety head by some chance give way, or the turbine gates or turbine gate valves, if such are employed, be opened, while the head gate is closed but the penstock full of water, the penstock might collapse by the vacuum created in its interior. Care must be taken to prevent the water in the vents or air inlets from freezing, as this would render them useless.

Expansion joints in penstocks do not seem to be so important as is often asserted, as most penstocks contain bends which permit of a limited movement, large enough to compensate for expansion and contraction, but in a straight penstock, rigidly held at each end, the strains due to changes in temperature are very heavy. The amount of these strains depends on the modulus of elasticity and the coefficient of expansion of the material; being for medium steel equal to 200 lbs. per sq. in. for a change in temperature of 1° F. For example, a straight steel penstock 9 ft. in diameter and made of ⅝-in. plate, has a cross-section of metal, including the laps, of about 220 sq. ins., and if held rigidly at both ends, will exert a thrust or pull of 44,000 lbs. or 22 tons for each degree of rise or fall in temperature; and assuming a rise and fall of 50° from a mean temperature of say, 40°, or a total range of from —10° to + 90° and further assuming that the penstock was erected at the mean temperature of 40°, the greatest thrust or pull will be 10,000 lbs. per sq. in., or 1,100 tons for the whole penstock. These figures show that an expansion joint should be provided in a straight penstock.

The lower end of a penstock should be held very securely in all cases to prevent forces due to temperature changes and other causes from throwing the turbines out of alinement, cracking the power house walls, etc.

Masonry piers are often damaged by the expansion and contraction of the penstock they support and the paint is rubbed off the penstock where it rests on the piers. Such unprotected places are hidden from view by the masonry, and are apt to corrode very quickly, as water is always retained between the surfaces of contact of the masonry and the penstock. It is therefore preferable to use steel piers on masonry bases similar to those proposed by the writer and employed in the water power developments at Shawinigan Falls, Que., and Chaudière Falls, Que., as shown in Fig. 42. Such steel piers are cheaper than masonry piers; they leave every part of the penstock accessible for painting and repairs and are free to swing on their bases, like inverted pendulums, to accommodate themselves to any movements of the penstock caused by changes in temperature. The uprights or posts of these piers are provided with bolt holes, to fasten to them the studs for a housing over or around the penstock when desired.

In a climate like that of the northern part of the United States and of Canada, penstocks must be covered or boxed in to protect them from the extreme cold, otherwise ice will form on their inner surfaces. At Grand'Mère, Que., a penstock of 14 ft. diameter, left unprotected during the first winter, was found to have its interior surface covered with solid crystal ice of from 12 to 18 ins. in thickness.

During midsummer the heat of the sun's rays, acting on an empty penstock, will often injure the paint, cause it to blister off, and perhaps overstrain the penstock itself, and a covering will, therefore, prove an advantage both in cold and hot weather. Even in a well-protected penstock, ice will be formed in severe weather when the water in it is allowed to remain stationary for more than a few hours at a time.

Where the ground under a penstock consists of earth it is preferable to bury the penstock, like the gas and water pipes in a city street. The cost will be about the same as when masonry piers are used, as the following figures will show: A penstock 4 ft. in diameter, supported by masonry piers spaced 15 ft. c. to c., requires piers of, say, $8 \times 6 \times 2$ ft. in mean dimensions, containing about 3½ cu. yds. of masonry each, and costing, including the necessary excavation for the base, at least $25 to $35 a pier. A ditch 6 ft. wide and 9 ft.

deep, in a length of 15 ft., contains 30 cu. yds., and at 50 cts. per cu. yd. for excavation and 30 cts. for filling and tamping, costs $24, to which may be added $6 for drain, lumber required, etc., making a price of $30 per length of 15 ft. Further, while the penstock buried in the ground has the best possible protection against extremes in temperature, an additional expense will be required to protect the penstock supported on piers.

Under the penstock, in the center of the ditch, should be a drainage ditch about 1 ft. square in cross-section, and filled with pebbles or broken stone, as used for concrete making. The penstock should rest on short wooden blocks and the main ditch should be left open during the first year, or for one winter season at least, after which the penstock is carefully inspected, recalked where leaky and repainted inside and outside, after which the earth is packed under and around the penstock and the ditch filled in, removing the wooden blocks as the work proceeds.

Wooden penstocks also deserve some mention here, although little used in the east. They are cheaper than steel penstocks, need less protection against extremes in temperature, and require no painting. Their interior surfaces are smoother than those of steel penstocks, but they should not be left empty long enough to allow the staves to dry. Redwood, yellow or Georgia pine and white pine can be recommended as a material for the staves.

DRAFT TUBES.

Although draft tubes have only come into use in comparatively recent years, their great advantage is now universally recognized as only the draft tubes made it practically possible to employ turbines on horizontal shafts, or to set turbines above the tail-water without losing part of the head.

The effect of a draft tube on a turbine may be compared to the effect of a condenser on a steam engine, as, like the condenser, the draft tube removes part of the back or counter pressure due to the pressure or weight of the atmosphere, while the water column above the turbine acts like the live steam behind the engine piston. The means employed for partially removing the back pressure are in the case of the turbine the suction caused by a hanging water column, and in the case of the steam engine the condensation of steam, creating a partial vacuum.

As the hanging water column in the draft tube is counterbalanced, or held in equilibrium, by the pressure of the atmosphere, its height or head cannot be greater than that of a water column exerting on its base a pressure equal to the atmospheric pressure.

At sea level the pressure of the atmosphere is 14.72 lbs. per sq. in., or 2,119 lbs. per sq. ft., and this will hold in equilibrium a column of water 34 ft. in height, if the water is at rest, but if the water is in motion then the atmospheric pressure has also to counterbalance that height or head, which is contained in the water in the form of velocity, and the height of the column thus balanced will be 34 ft., less the velocity head corresponding to the speed of the water, or $34 - \frac{v^2}{2g}$, in which v is the velocity of the water in the draft tube in feet per second, and g the acceleration of gravity, equal to 32.2. With the speed v equal to 46.8 ft., the velocity head becomes 34 ft. and the height of the water column that will be balanced by the atmospheric pressure becomes $34 - \frac{46.8^2}{2 \times 32.2}$, which is equal to zero.

In a draft tube the water column can, therefore, not have a greater height in feet than $34 - \frac{v^2}{2g}$, and if the vertical length of the draft tube is more than that, the water surface in it will remain at an elevation of $34 - \frac{v^2}{2g}$ ft., and the part of the draft tube above this level will contain a vacuum, which means a loss of head equal to the height of the empty space.

The considerations and figures just given are theoretical only, and have to be modified in practice.

The height of the water column or draft head, acting on a radial or parallel flow turbine on horizontal shaft, is the vertical distance from center of shaft to the tailwater level, while the draft head of a radial turbine on vertical shaft is the vertical distance from the level of the center of the guide bucket discharge openings to the level of the tailwater.

However, not the whole of this draft head can be utilized in the turbine, and to obtain the effective draft head the sum of the various losses has to be deducted from the total draft head of 34 ft. These losses are due to the friction of the water in the draft tube, to the change in the speed of the water between the turbine runner and the lower end of the draft tube, and to the momentum or velocity still contained in the water while leaving the draft tube.

Air bubbles rise in water with a speed of about 12 ins. per second, and to prevent such bubbles from rising inside of a draft tube and to carry off the air, when starting a turbine with the draft tube filled with air, the speed per second of the water while leaving the draft tube, when the turbine is working with full capacity, should not be less than 2 ft. for turbines with steady loads, and always working at or near their full capacity, not less than 3 ft. for turbines with moderately variable loads, and always working with more than half of their full capacity and not less than 4 to 6 ft. for turbines with violently fluctuating loads and working at times only with small fractions of their full capacity.

The absolute velocity in feet per second with which the water issues from the runner buckets, that is, the velocity relative to a stationary object, may be taken as,

$$v_1 = 0.285 \sqrt{2 g H}$$

for large size turbines and low heads, say 10 ft.; as

$$v_1 = 0.2 \sqrt{2 g H}$$

for medium size [illegible]es and medium head, say, 100 ft.; and as,

$$v_1 = 0.167 \sqrt{2 g H}$$

for small size turbines and high heads, say, 500 ft., in which H is the total head in feet acting on the turbines. This is for turbines of the European type. The writer could find no reliable data in regard to the absolute discharge velocity of American turbines, but it may be stated that these velocities are higher for the American than for the European type.

The heads corresponding to these discharge velocities are entirely lost, except when draft tubes are used, which discharge the water at lower speeds, or, stating this in another way: Of two similar turbines, working under the same head, but one set above the tailwater and provided with a draft tube, while the other is set on or below the level of the tailwater, and not provided with a draft tube, the turbine using the draft tube will always give the higher efficiency, and the efficiency of a turbine working on or below the level of the tailwater may be increased by the addition of a draft tube, as the draft tube acts in exactly the same manner as the Boyden diffuser, making power available out of the water discharged from the runner by retarding the velocity of the water.

A few examples will illustrate this, taking in all cases the speed of the water while leaving the draft tube, v, equal to 3 ft. per second, and the corresponding velocity head,

$$h = \frac{v^2}{2g} = \frac{3^2}{2 \times 32.2} = 0.14 \text{ ft.}$$

H and v_1 have the same meaning as above, h_1 is the velocity head for v_1 and G is the gain in head, due to the retardation of the water by the use of a draft tube. Then we have:

H =	10 ft.	100 ft.	500 ft.
v_1 =	$0.285 \sqrt{2 g H}$ = 7.23 ft.	$= 0.2 \sqrt{2 g H}$ = 16.05 ft.	$= 0.167 \sqrt{2 g H}$ = 29.97 ft.
$h_1 = \frac{v_1^2}{2g}$ =	$0.285^2 \times H$ = 0.796 ft.	$= 0.2^2 \times H$ = 4 ft.	$= 0.167^2 \times H$ = 13.94 ft.
$G = \frac{v_1^2 - v^2}{2g} = h_1 - h$ =	0.656 ft.	= 3.86 ft.	= 13.8 ft.
G in per cent. of H =	6.56%.	= 3.86%.	= 2.76%.

The gains here shown are theoretical only and cannot be reached in practice, but a well-arranged draft tube should realize from 66 to 75% of the theoretical gain.

Conical or tapering draft tubes, changing the speed of the water gradually, should always be used, and the present practice of having the same cross-sectional area for the entire length of the draft tube must be condemned, as the water, issuing from the runner with a velocity several times greater than the velocity of the water column in the draft tube, strikes the latter and is so suddenly retarded that most of the power made available by the retardation of the water is lost in the shock.

It must also be borne in mind that to reduce the speed with which the water leaves the runner to the speed with which it leaves the draft tube, requires a certain minimum length of draft tube, this minimum length being the greater, the larger the diameter of the draft tube is. It will therefore often prove an advantage to increase the length of the draft tube, without increasing the draft head, by curving, or better, by inclining the draft tube.

The draft head that can be employed in practice is only a part of the theoretical limit of 34 ft. less the velocity head, the practical limit decreasing with increasing diameters of draft tube.

The writer, by computing the equivalents in English measurement of the metric values of a table given in a German standard work on turbines, and plotting a curve from the results, has deduced the following table of the greatest draft head that may be employed in practice, under average conditions, and for different diameters of draft tube:

Draft tube diameter in feet.....	0.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Draft head in feet.....	32.5	30	27.5	25	22.5	20	18	16	14.5	13	12	11	10.5	10	9.5

From the draft heads here given the velocity head, corresponding to the speed with which the water leaves the draft tube, or $h = \frac{v^2}{2g}$, has to be deducted, and the result will be the greatest permissible draft head to be employed. For conical draft tubes, this table shows the greatest height above the tailwater at which a given diameter of draft tube may be used; this height is, of course, to be corrected for the velocity with which the water is discharged from the lower end of the draft tube in the same way as just stated. For example, a conical draft tube must not be more than 9 ft. in diameter, at a height of $13 - \frac{v^2}{2g}$ ft. above the tailwater level.

Under average conditions these figures must not be exceeded if perfect working of the draft tube is to be insured, but in general a higher draft head may be used with turbines with steady loads and always working with their full capacity, while with turbines liable to great fluctuations in their loads and working at times only with small fractions of their full capacity, the draft head should be smaller than given in the table.

The dip, or the distance to which a vertical draft tube reaches below the level of the tailwater, should be 6 ins. to 12 ins. for short and small draft tubes, increasing to 20 ins. to 24 ins. for long and large draft tubes. In general, it may be said, that a greater dip permits a greater draft head.

When a very high draft head is employed, especially in connection with large draft tubes, the water has a tendency to pulsate or oscillate in the draft tube, and, if the turbine is subject to sudden changes in load and provided with a quick acting governor, the pulsations will increase to such an extent that they not only have the effect of a varying draft head acting on the turbine, and thus be detrimental to good speed regulation, but these pulsations may even wreck the turbine

With the turbine gate closing quickly the momentum of the water column in the draft tube will cause that column to break, creating a vacuum, but as soon as the momentum has been arrested, the atmospheric pressure will throw the water column upward again, striking the turbine runner with great force.

It should be stated here that conical draft tubes are less liable to pulsations and can therefore be employed with greater draft heads, than cylindrical draft tubes. Conical draft tubes are also better able than cylindrical ones to form the draft when the turbine are started and to retain the draft when the turbines are running with light loads.

In a large and long draft tube, when the turbine is started with the draft tube filled with air, or when running with only a small fraction of the full load, the water is liable to crowd to one side and tumble or drop through the draft tube without expelling the air or forming a suction, and the draft head is thus lost. Curved or inclined draft tubes are more likely to act in this manner than vertical draft tubes. It is very probable that many turbines may be found running with their draft tubes partly filled with air, and thus losing the entire draft head without the fact being known to the parties in charge of the plant.

Gates for closing the lower end of the draft tube and used for filling them with water before starting the turbines, or for reducing the discharge area, when working with part load, have been used to some extent in Europe, but they are expensive and ponderous for large turbines, and it is not probable that they will be adopted in America.

The draft tube should be strong enough to withstand the atmospheric pressure to which it is subjected, and which tends to collapse the draft tube. The pressure, p, in pounds per square inch, at any vertical distance, d, in feet, above the tail-water level, is equal to $p = \frac{14.72}{34} \times d$, but can, of course, never exceed the pressure of the atmosphere, or 14.72 lbs.

In nearly all modern engine rooms of any importance will be found gages indicating the pressure in the steam chest, receiver and condenser and similar gages, used in conection with turbines enclosed in cases, would be of immense value both to the superintendents in charge of water power plants, as showing them at once if the turbines are working properly, and to the hydraulic power engineers and the turbine builders, as giving them valuable information concerning the proper proportions and arrangement of the different parts forming an installation.

Of such gages a pressure gage, indicating the pressure of the water near the entrance of the guide buckets, and a vacuum gage, indicating the amount of draft or suction near the discharge openings of the runner buckets, would be the most important.

COST OF WATER POWER.

Whenever the development of a water power, for the purpose of selling water or mechanical or electrical energy is under consideration, the most important question to be decided is: What is the limit of cost per horse-power that may be expended for a development and still leave the plant a financial success, or what is a reasonable price to be charged per horse-power per year?

A great amount of data has been published in regard to the cost of hydraulic power and power plants, but as water powers present an infinite variety of conditions, such prices of other plants should only be used with the greatest precaution. A few general figures, intended to apply to conditions at present prevailing in the northern part of the United States and in Canada, may be given here:

A water power electric plant, including transmission line and substation, where such are required, but without the local distribution, should not cost more than $75 per electrical horse-power if situated in a remote location or in a farming district; but up to $125 may be expended per electrical horse-power for power plant, transmission and substation, if the power can be sold in a large city or industrial district.

The price charged for power water per gross horse-power per year, delivered at or near the customer's turbines, may be taken at from $5 to $10, the lower figure being for remote locations, low heads and large powers, and vice versa. The price of $10 to $20 per mechanical horse-power per year at the power house, or of $20 to $40 per electrical horse-power per year, delivered to the customer, may be taken as the limits paid at present. Here, again, the lower price is for remote locations and large powers, and vice versa.

It is also safe to state that in a climate such as that of the northern part of the United States and in Canada, with its long and severe winters, it does not pay to develop a water power if the power produced will cost more than 75% of the amount for which steam power could be produced in the same locality.

In Canada, with the great number of water powers yet undeveloped or only partly utilized, it must be regarded as poor policy to install a larger plant than can be run at all stages of the water, or to have a great proportion of power dependent upon storage lakes during the months of low water.

A UNIFORM NOMENCLATURE FOR HYDRAULIC ENGINEERING.

Before closing this paper, one other matter may be mentioned as deserving the attention of the profession. In hydraulic power engineering there exist so far no generally accepted terms, and not only are several different names given to most things, but what is worse, the same terms are often used with different meanings.

To start a movement towards uniformity, the writer would suggest here a few terms and meanings for universal acceptance, as follows:

For "water wheel" say "turbine" whenever a turbine is meant.

For "Jonval" turbine say "reaction" turbine.

For Girard, Pelton, impulse or free deviation turbine say "action" turbine.

For Fourneyron or Boyden turbine say "radial outward flow reaction" turbine, or else simply "outflow reaction" turbine.

For Francis turbine say "radial inward flow reaction" turbine, or simply "inflow reaction" turbine, as this type is usually understood by the name Francis turbine. While it is not likely that the term Francis turbine will go out of use, the term inflow reaction turbine should always be used where an exact expression is of importance, as in contracts, for the reason that Mr. Francis also designed outflow reaction turbines.

For "parallel flow" turbine say "axial" flow turbine, or axial turbine.

For "segmental feed" turbine say "partial feed" turbine, or "partial" turbine.

For one, two, three, four, five or six turbines on one shaft say single, double, triple, quadruple, quintuple or sextuple turbine.

For "draft chest" or "camelback" say "drafttee."

For "butterfly gate" say "wing-gate."

For "feeder pipe" or "water feeder" say "penstock."

For open flume say "turbine-chamber" whenever a turbine chamber is meant, leaving the term "flume" to mean a water conductor only, built of wood, steel or masonry, and carrying water not under pressure.

For the distance to which a vertical draft tube reaches below the surface of the tailwater, say dip of draft tube.

For speed of water in the cylindrical part of the penstock say "penstock speed."

For speed of water, while leaving or quitting lower end of draft tube, say "draft tube speed."

For the part of the head that is above the turbine say "pressure head."

For the part of the head that is utilized by means of a draft tube, say "draft head."

The water available under the head utilized should be called "power water," corresponding in meaning to the term live steam.

The water having descended either through the turbines or over the falls, should be called "tailwater," corresponding in meaning to the term exhaust steam.

The terms horizontal or vertical turbine should always mean a turbine on a horizontal or vertical shaft, and never one revolving in a horizontal or vertical plane, as it is now sometimes understood.

The area left open or clear by the regulating gate or gates for the passage of the water should be called gate opening. At present the term gate opening or gate is nearly always used to mean the amount of water flowing through the gate opening, but this amount should be designated by discharge; for example, instead of saying: "This turbine, with five-eighths gate opening, gave an efficiency," etc., should be said: "This turbine, with five-eighths discharge, gave an efficiency," etc., whenever the discharge is meant.

The motor furnishing the power for actuating the regulating gates of a turbine, and usually controlled by a speed governor, should be called a relay. In Europe the term servomotor is used for such auxiliary machines.

The terms here suggested for universal acceptance are already used to a greater or less extent; they are not only simple and easily to be remembered, but most of them directly express their own meaning.

As there are four different efficiencies to be considered in connection with water-power developments, specifications and contracts should always state which efficiency is meant; also, where the tests are to be made.

These four efficiencies are: (1) The hydraulic efficiency. (2) The mechanical efficiency. (3) The efficiency of the turbine as a whole, being the product of the hydraulic and mechanical efficiencies. (4) The efficiency of the plant.

THE KANSAS CITY, MEXICO & ORIENT RY.

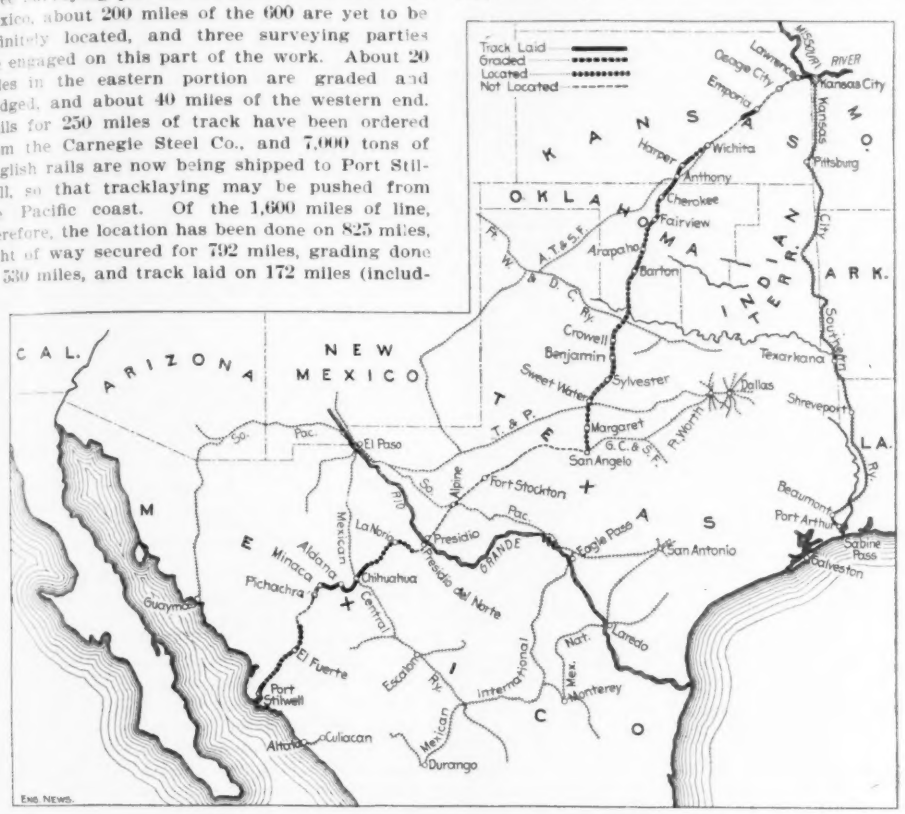
New railways of over a thousand miles in length have become very rare in this country owing to the vast network of the existing railway systems. On account of its length, therefore, as well as for other reasons, the Kansas City, Mexico & Orient Ry., now under construction, is of somewhat exceptional interest. This line is in fact one of the most ambitious and important projects now in progress of execution, being designed to form a new trunk line 1,600 miles long from Kansas City to a new port on the Pacific coast of Mexico, with provision for steamship connections to Oriental and South American ports. This line was projected by Mr. A. E. Stilwell, who is President of the company. Mr. Stilwell will be remembered as the projector of the Kansas City, Pittsburg & Gulf Ry., which was designed to open up a new and direct route from Kansas City to a new port on the gulf, and this project he successfully carried through to completion a few years ago. The K. C., P. & G. Ry. was described in our issue of Feb. 17, 1898, but subsequent financial troubles led to the reorganization of the company under the name of the Kansas City Southern Ry.

The Kansas City, Mexico & Orient Ry. starts from Kansas City over its own rails, and runs in a general southwest direction through Kansas, Oklahoma and Texas, and across the northern part of Mexico to a port named Port Stilwell on a landlocked harbor known as Topolobampo Bay on the Gulf of California. The general route is shown on the accompanying map, which also shows the progress of work up to December, 1902.

The project first acquired definite shape in 1900, but has been pushed steadily forward, and active work is now in progress at several points. The line is all new construction, no existing roads being utilized, with the exception of the Chihuahua & Pacific Ry. in Mexico, which is 125 miles in length. The line commences at Kansas City under the name of the Kansas City Outer Belt & Electric Ry., which will be a terminal line connecting with the various railways entering the city, and affording access to any terminal. A local electric traffic may also be maintained. This line will have six miles of double track main line and 15 miles of yard and terminal tracks. It will include also two new bridges over the Missouri River and the Kansas River. The Texas law requires railways in that State to be owned by local corporations, and that part of the line lying in Texas is therefore incorporated under the name of the Panhandle & Gulf Ry.

The entire route, however, is controlled by the same capitalists.

In Kansas, about 150 out of 225 miles are located, 50 miles graded, and 10 miles of track laid. In Oklahoma, 200 miles are located, 107 miles graded (50 in the northern and 57 in the southern part), and on 74 miles the track has been laid and bridges built. In Texas, 250 out of 560 miles have been located, and 160 miles graded, while three surveying parties are now in the field. In Mexico, about 200 miles of the 600 are yet to be definitely located, and three surveying parties are engaged on this part of the work. About 20 miles in the eastern portion are graded and bridged, and about 40 miles of the western end. Rails for 250 miles of track have been ordered from the Carnegie Steel Co., and 7,000 tons of English rails are now being shipped to Port Stilwell, so that tracklaying may be pushed from the Pacific coast. Of the 1,600 miles of line, therefore, the location has been done on 825 miles, right of way secured for 792 miles, grading done on 530 miles, and track laid on 172 miles (including the Chihuahua & Pacific Ry.). Track material has been ordered for nearly 350 miles more. Two sections of line in Kansas are already in operation.



MAP OF THE KANSAS CITY, MEXICO & ORIENT RY.
Milnor P. Paret, M. Am. Soc. C. E., Chief Engineer.

The contract for the work from Kansas City, Mo., to Fairview, Okla., 335 miles, has been awarded to the Union Construction Co., of Kansas City. The contract for about 1,100 miles across Texas and Mexico has been awarded to the International Construction Co., of Kansas City. The intermediate portion is being built by separate contracts, and the railway company is doing some of its own work at the Pacific end. The Kaw Valley Construction Co. has a large part of the grading, and many subcontracts have been let. Grading and tracklaying are in progress at various points, and a considerable amount of concrete bridge masonry has been built, but very few steel bridges have yet been erected. Owing to the congested condition of the steel and bridge markets in this country it is probable that some of the bridge contracts will be placed in Europe. At the Pacific end, Oregon fir is being used for bridges, and California redwood for ties. In Texas, long-leaf yellow pine is used for both purposes.

No extensive harbor works will be required at the Port Stilwell terminal. There is a depth of 24 ft. of water close to the shore of the bay, and 20 to 22 ft. is maintained almost uniformly over the bar. A line of coasting steamers is now in operation, and arrangements have been made for lines of ocean steamers to South American and Oriental ports. This will only be a side issue, however, as there will be a very large traffic developed along the line. In Mexico, especially, mining districts will be served which have now no railway accommodation. Here all ore has to be carried on mules or burros to smelters at great distances, and only high-grade ores can stand the cost of this mode of transportation. Low-grade ores are therefore practically valueless until railway transportation is available, and it is reported that large quantities of such are awaiting development.

Considerable care and money have been expended in securing a low-grade line, in order to effect future economy in operation. The maximum grade for about 330 miles out of Kansas City is 0.5%, and beyond this to the Mexican boundary (the Rio Grande River), the maximum will be 1%, which will also be the maximum on the Pacific slope. On the mountain division in Mexico, however, grades of 2% and curves of 9° are used, but it is said that the grades and general location are much easier than on the mountain divisions of any other transcontinental lines. The mountain division also avoids river crossings as far as possible, so that the amount of bridge work is comparatively small.

The principal officers of the Kansas City, Mexico & Orient Ry. are as follows: President, A. E. Stilwell; General Manager, E. Dickinson; Chief Engineer, Milnor P. Paret, M. Am. Soc. C. E. The general offices are at Kansas City, Mo.

SOME FEATURES OF THE LABOR SYSTEM AND MANAGEMENT AT THE BALDWIN LOCOMOTIVE WORKS.*

By John W. Converse.†

The secret of the success of the American manufacturer—that which enables him to turn out a uniformly good article in a short time and at a low cost, lies in the energy of his production. The chief element in this production is the personnel, the character and method of treatment of the labor employed. The American manufacturer has realized the fact that to get the best result and the largest output from his plant the interest of his laborer and himself must be in harmony. This is not a sentimental theory but sound business policy. It is to the advantage of the employer to pay high wages for good work quickly and accurately done, rather than to pay low wages for slow and slovenly work. The laborer does better when he realizes that his work is appreciated and that increased effort and diligence meet with substantial recognition and reward. The workman is encouraged to exercise his brain and is given extra pay or promoted for having done something or discovered something to the advantage of his employer.

*Extracts by permission from the "Annals of the American Academy of Political & Social Science" for January.
†Philadelphia, Pa.

Philadelphia's prominence as a manufacturing city affords a labor market unsurpassed in quality and quantity anywhere in the United States. The large permanent population of skilled mechanics employed in the iron and steel industries of Philadelphia gives an abundant force from which to draw. These men are mostly Americans and of a high grade of intelligence.

Some features which may be of interest in the method of management of labor at the Baldwin Locomotive Works will be treated in this paper.

The capacity of the establishment is 36 locomotives a week. Orders are allotted spaces in the week in which delivery is promised. If a new design has to be made, the drawing must be completed and data submitted to the purchasing department for ordering material before the work is ordered in the shop. All parts of locomotives and tenders, except boiler and tank plates, steel tires and steel castings, chilled wheels, boiler tubes and special patented appliances, are made from the raw materials. All parts ordered by the purchasing department are ordered for a definite locomotive or a number of locomotives of a particular class and must be invoiced as such.

The foremen of the different shops where the various component parts of the locomotive are made are furnished a list, bearing the class designation of the locomotives for which the parts made in his shop are intended. When the drawings are furnished him he allots the work and sees to it that it is finished by the time specified on the list. Each part is marked with the class designation of the locomotive for which it is intended. Each workman reports to the timekeeper through his boss or through the foreman his time for each piece and the locomotive for which the piece was intended. All these component parts are assembled in the erecting shop at the appointed time and, by means of this unit system, the finished locomotive is put together without confusion or unnecessary delay.

A further advantage of this unit system of production appears in the accounting department. Two sets of books are kept—a financial and a manufacturing set. In the financial department accounts are kept of sales, purchases and expenditures. In the manufacturing books a separate account is opened with each locomotive and the material entering into its construction and the labor expended on it are charged against that locomotive. At the end of the year these two sets of books must balance each other. By this method the actual cost of each locomotive is obtained with accuracy and, allowing for fluctuations in price of raw materials, correct quotations can be made for any class of engine.

It is upon this unit system of locomotive classification, by means of which the identity of each locomotive is preserved, that the system of the labor organization and management of the establishment is based. Having mentioned the chief points in the method of manufacture let us glance at the personnel of the men.

About 13,000 men are on the pay-rool of the Baldwin Locomotive Works at the present time. The majority of these are Americans, although representatives of nearly every nationality on the face of the globe are found among them. The only requirements of an employee are a good record, a fair amount of intelligence, and a willingness and ability to do the work. About 10% of the total numbem employed are boys under the age of 21 years. A large proportion of these are apprentices being taught a trade.

A great variety of skilled labor is employed. A skilled laborer is here understood to mean one who is familiar with the use of a tool, a machine or a process; an unskilled workman is one who cannot run a tool but does ordinary laboring work. The number of skilled and unskilled workmen is divided in the ratio of about two-thirds skilled and one-third unskilled.

Wages are reckoned by the hour and not by the day. Unskilled laborers have a per-hour rating. Piece-work wages, for convenience in accounting, are equated to a per-hour rate. A piece-worker can earn the equivalent of from 18 to 50 cts. an hour according to the character of the work and the ability of the man. The average wage of skilled labor is 30 cts. per hour. The average wage of unskilled labor is about 16 cts. per hour. The men are paid on Friday for their time in the preceding week. Each man has a number which is assigned to him on entering the employ of the Baldwin Locomotive Works. Each shop has a given block of numbers for its quota of men. When the whistle blows to stop work at 6 o'clock on Friday the men in the different shops file by certain booths, each giving his number and receiving his pay envelope which contains in coin the amount due him and on which is written the name, number and amount. Payment is made in coin to insure accuracy and a saving of time in making up the amounts.

The shops are run continuously 23 hours a day and the force is divided into day and night shifts. The day shift is on at 7 and off at 6, with an hour from 12 to 1 for lunch; the night shift goes on at 6 and off at 7 in the morning, having 20 minutes for lunch at midnight, which is not deducted from their time. A monitor whistle blows at 3 minutes before the hour at 7 and 1; at the hour each workman is required to be at his place and commence work when the signal is given. When late, a workman must secure a "late pass" at the office, which must be presented to the watchman at the gate before he is allowed

to report for work. A time-worker is fined for being unpunctual, an hour's time for the first hour or fraction thereof if he is late. Except in rare cases men are not allowed to report after 8 a. m. Piece-workers are fined one hour's rate no matter how late they are. Workmen quitting or preparing to quit before the stop signal is given are fined one hour's time. As time is money when so many men are employed the rules regulating attendance are strictly enforced. The moral effect of the "late pass" on the foremen's desk is quite an aid to punctuality.

Each workman must know before commencing a piece of work, that it will finish to the sizes marked on the sketch or card given him and whether the work is to be completed by himself or others. A rigid system of inspection is enforced in the shops to insure the work being done properly and accurately. Damage for spoiled work is charged to the workman, unless occurring from a reasonable cause, and must be reported at once to the foreman. A workman accepting a piece of work from another to finish is held responsible for any errors in the work of his predecessor. Work must be kept neatly filed and properly marked with the class designation and number of the locomotive for which the piece is destined, and each succeeding workman must see that the mark is continued on work finished by him. All work, as soon as completed at one machine, must be delivered to the next succeeding machine. Economy in the use of material of all kinds, oil, waste, emery, files, etc., is strictly enjoined on every workman.

Each employee is responsible for the tools placed in his charge on commencing work, and upon leaving the employ of the establishment, he must deliver the key of his box or drawer to the foreman and satisfy him that the stock of tools is complete and in proper order. Each workman is required to keep his bench, vise, lathe, forge, machine, or whatever tool or place at which he is employed, cleaned and free from rubbish. Careless damage to a tool is charged to the workman.

A workman whose machine breaks down through no fault of his own, or while waiting for work, receives a per hour rate proportionate to his piece-rate, at the discretion of the foreman. A workman running two or more machines on piece-work, however, is not paid an hour rate for time lost by one machine on account of a break down, or while waiting for work.

Workmen are required to report to the timekeepers as follows: Number of hours per day; name of machine; designation of engine or job for which the part is made; when commenced and when finished. Piece-workmen are required to return and charge all their completed work in the week in which it is finished. They do not receive pay for their work unless they comply with this regulation. Piece-workers personally see that timekeepers get their correct time daily, they also must enter on their slates, each evening before leaving the works, their time for the day.

Having glanced at the personnel of the workmen we will discuss some phases of the system which present themselves. The unit system of production makes it desirable that all work should be turned out by the piece. In the Baldwin Locomotive Works, two forms of piece-work are represented, viz.: Piece-work proper, where the workman is paid according to the quantity produced; and a contract system, where sub-foremen, called contractors, are entrusted with the execution of a portion of the work on a locomotive; for example, the entire construction of the cylinders, or the erection of a certain number of tanks. The contractor has entire charge of the job, seeing that the raw material is delivered in time, that the men are prompt and diligent, that tools are in repair and machines do not break down. The contractor is paid for the job, the firm paying directly to each workman for the labor on the job. The contractor cannot, therefore, get more than the amount due him on any one job by curtailing the wages of his labor. The contractor is a piece-worker on a larger scale. As he is paid by the job, he has an incentive to turn out his work as quickly as possible and to get as much work as possible out of the men under him.

The following occurrence illustrates the value of the contract system in expediting work. Tanks are built exclusively in one of the shops comprised in the works. The frames and bodies are built on the second and third floors and are taken in an elevator to the fourth floor, where they are erected over the trucks. The elevator broke down one day and the job was held up. The contractor was losing money as he could not turn out his tanks. The elevator was running inside of two days. In the ordinary course of events two weeks would probably have been taken to put it in working order.

The contract and piece-work systems insure quantity of product; a rigid system of inspection insures quality of product. In order to insure good workmanship an extremely rigid system of inspection is maintained and contractors and piece-workers are held to strict account if the quality of their work falls below the standard.

Another feature of the piece-work system, which is at the same time an advantage and a disadvantage, is the specialization which it naturally entails. In the kind of machine work done at the Baldwin Locomotive Works the same operation is performed over and over again many times. The piece-worker, doing the same thing repeatedly, soon finds out the best and quickest way to do the work, and, as he can make more money doing his specialty, he is naturally unwilling to be shifted to another machine or another class of work. The tendency of this specialization is to limit the workman to a single process, and, as a result, the general mechanic has threatened to become practically extinct, to the detriment of manufacturing interests generally.

To remedy this disadvantage an apprenticeship system was inaugurated at the Baldwin Locomotive Works in March, 1901. The apprentices taken on are divided into three classes, as follows:

First class apprentices comprise boys who have had a good common-school education and are not over 17 years and 3 months of age. They are indentured for four years. An apprentice of this class is required to attend at least two evenings in each week during the first three years of his apprenticeship, free night schools, such as during the first year will teach him elementary algebra and geometry, and during the remaining two years shall teach him the rudiments of mechanical drawing.

Applications for indenture as second class apprentices are considered from boys who have had an advanced grammar or high school training, and are not over 18 years of age. The term for this class is three years. The apprentice is required to attend night schools, which shall teach him the rudiments of mechanical drawing, for the first two years of his indenture.

The third class indenture is in the form of an agreement made with persons 21 years of age or over, who are graduates of colleges, technical schools, or scientific institutions, having taken courses covering the higher mathematics and the natural sciences, and who desire to secure instruction in practical shop work.

The indentures or agreement in each case place upon the firm the obligation to teach the apprentice his art thoroughly and to furnish him abundant opportunity to acquire a practical knowledge of mechanical business. The firm is also bound to retain the apprentice in service until he has completed the term provided for in the indenture or agreement, provided his services and conduct are satisfactory. In all cases the firm reserves the right to dismiss the apprentice for cause.

The rates of pay in the different classes are as follows:

Apprentices:	1st year, per hour.	2d year, per hour.	3d year, per hour.	4th year, per hour.
First class ..	5 cts.	7 cts.	9 cts.	11 cts.
Second class ..	7 cts.	9 cts.	11 cts.	
Third class....	1st 6 mos. of 1st year, 13 cts. per hr.			
	2d 6 mos. of 1st year, 16 cts. per hr.			
	1st 6 mos. of 2d year, 18 cts. per hr.			
	2d 6 mos. of 2d year, 20 cts. per hr.			

In addition to the rates mentioned above, apprentices of the first class receive an additional sum of $125, and apprentices of the second class an additional sum of $100, at the expiration of their full terms of apprenticeship respectively.

The apprentices are under the direct supervision of a superintendent, and a careful record is kept of the performance of each. The apprentices are put to work in the shop on the different machines, millers, slotters, planers, lathes, boring machines, etc. They are shifted to a different machine every three months and an account of their work entered in the superintendent's book. Apprentices of the third class are shifted as often as they wish from one machine to another. On the completion of his indenture, if he wishes it, and his record has been satisfactory, the apprentice can secure a good position in the works, at the start generally as track boss, inspector or in some such capacity. There are about three hundred apprentices on the books at the present time; about one hundred of them are in the first, about sixty in the second and about forty in the third class. The object is to turn out good, all-around machinists and good results are hoped for from the system.

The policy of the firm is to make the interest of the men identical with its own. Hard work is required, but high wages are paid, ingenuity is encouraged, and intelligent and faithful work is liberally rewarded. Piece-rates are seldom cut, and then only on account of the introduction of a time-saving tool, in which case the workman shares in the gain accruing. The policy is to maintain a uniform piece-rate for all the men doing a certain class of work. If one man shows especially marked ability, he may be shifted to another job, usually being made a contractor or sub-foreman. The policy of the establishment is to make promotions from within; foremen, bosses or superintendents are not imported. There are no hereditary rights to important positions.

Strikes are practically unknown. If a man has any grievance he can submit it to the superintendent and he knows that his complaint will receive careful consideration and that he will be dealt with fairly. No one is questioned, when he enters the employ, whether he is affiliated with a trades union or not, but trades-unionism does not flourish at the works.

A pleasing and noteworthy feature of the attitude of the men is the esprit de corps which prevails. They realize that their employers are doing their best for them and only ask in return the best work of each man. Every man is proud of the establishment he works for, the oldest of its kind in the country, and every man is proud to be known as a Baldwin man.

AN ARTIFICIAL UNDERGROUND WATER SUPPLY AT GOTHENBURG, SWEDEN.

A unique method of developing a water supply is in use at the water-works of Gothenburg, Sweden. Its aim is to so utilize a plentiful supply of suspicious or even dangerous surface water, together with a natural but limited bed of water-bearing material, as to secure, in effect, a large supply of naturally purified underground water from a limited area. At the same time it is claimed that better bacterial results than are possible with ordinary sand filter beds are secured, and at a greatly reduced cost for construction and operation. The means adopted were the provision of large, cheaply constructed filter basins, into which river water is pumped, and tubular wells and a collecting conduit at a distance from the filter basins. The water from the basins can reach the wells only after slowly percolating through the soil, and it is claimed that the supply is rendered largely independent of the rainfall on the collecting area naturally tributary to the wells. The system has therefore been termed an "artificial underground water supply."

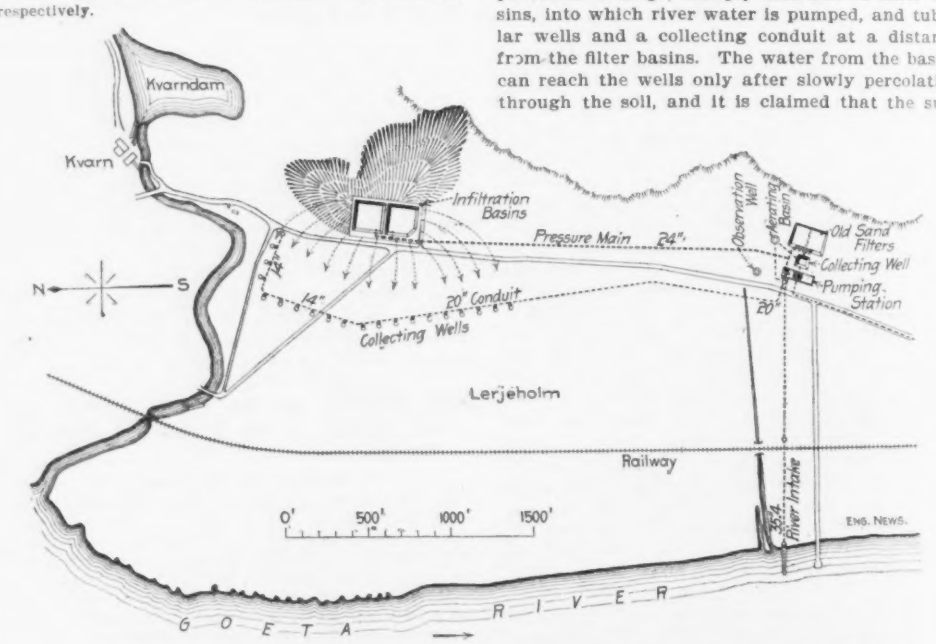


FIG. 1. PLAN OF WORKS TO DEVELOP ARTIFICIAL UNDERGROUND WATER AT GOTHENBURG, SWEDEN.

The engineer for this interesting water supply development is Mr. J. Gustaf Richert, of Stockholm, Sweden, and through his kindness we are enabled to describe the works named, and to give, in addition, some arguments advanced by

Mr. Richert in favor of a wide adoption of this plan.

In 1890, acting under the advice of an engineer named Salbach, "a complete hydrological investigation" of the valley of the Göta Elf River was made, and artesian water under clay was found. The water contained so much chlorine and ammonia that it was considered unfit for drinking, so in 1891 the town council adopted a plan made by Mr. Richert for six covered filter beds, to treat the water of the Gota Elf River. In 1891-3 two of these filters, with the necessary pumping plant, were built, supplementing the old supply from Lake Delsjön. In 1895 more water was needed, but before adding to the filters it was decided to make further studies of the possibility of utilizing the natural filter bed of the Göta Elf River. On the strength of experimental results obtained in 1896 the works already described in outline were constructed in 1897-8, and water from them was first pumped to the town on Jan. 17, 1899. It is claimed, however, that the artificial ground water did not reach the wells before the beginning of April, 1899, the new supply meanwhile being drawn from the ground in the vicinity of the wells.

The first proposal was to develop an ordinary ground water supply by means of wells, advances since 1890 in the knowledge of the significance of high chlorides and ammonias in ground waters leading those concerned to believe that the water from the Gota Elf valley was safe after all. But the yield from this source appearing to be limited to only 528,000 gallons a day, and in addition

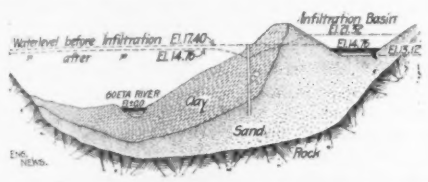


Fig. 2. Sectional Sketch of Artificial Underground Water Development, Gothenburg, Sweden.

the water having been found to contain sulphuretted hydrogen, some other course became necessary. The sulphuretted hydrogen could be removed by aeration in a basin located above the pump-well at the old filter plant, and experiments showed that the yield from the wells could be increased by the method already described.

Accordingly, it was decided to pump the river water to filter basins dug in a continuation, at a higher level, of the water-bearing sand in which the proposed wells were to be located. The plan, Mr. Richert states, was

to sink the water into the bed of sand and finally, after months of filtering, to make use of it as a pure and improved artificial ground water.

Two filter basins were built, and, at a distance of about 650 ft., 20 wells were sunk and connected with a gravity conduit leading to the pumping station, apparently terminating in an aerating basin. A plan of the works is shown by Fig. 1, while Fig. 2 is a sectional sketch through the filter basins and wells and across the whole valley. The elevations on the section show the relative heights of the various water levels.

The basins have a combined bottom surface of about 53,800 sq. ft., and "with a filtering velocity of 4.2 ft. let through 1,700,000 (U. S.) gallons of water in 24 hours," which is about 1,370,000 gallons per acre per day. Observations in a pipe sunk between the two basins show that the loss of head increases from 0.49 ft., just after cleaning the sand surface to from 2.3 to 3.28 ft., after which the water is shut off and the basins cleaned by scraping up and removing the fouled sand.

One basin can be cleaned while water is being pumped to the other, and the basin in service may be worked at double speed for a day or two without harm.

Each of the 20 tubular wells is 8 ins. in diameter, and the average depth is about 100 ft. The collecting conduit is from 14 to 20 ins. in diameter. Wells Nos. 1, 7 and 18 are not connected with the conduit, but are used as gaging stations. The combined yield of the 17 wells drawn upon is 74 liters, or about 20 gallons per second, which gives a daily rate of 1,728,000 gallons, about as stated for the yield of the filter basins. The yield of the several wells ranges from 1 to 18 liters per second, the average being 4⅓, but a group of five wells at one end of the line (Nos. 15, 16, 17, 19 and 20) gives 42.5% of the yield, or about 60% of the total, and No. 15 alone yields 18 liters. Unfortunately the order of the numbering was not given on the original of the accompanying plan.

Chemical analyses of the natural ground water in the vicinity of the wells, before the new works were constructed, showed 211 mg. per liter of chlorine and 4.1 and 1.4 parts, respectively, of ammonia for two different wells. After the filter basins had been in operation long enough to allow the water passing through them to reach the wells, four analyses, made in April, May, July and August, 1899, showed an average of 88 parts of chlorine and in only one case (0.6 mg. per liter) more than a trace of ammonia. The samples of artificial ground water were taken from the aerating basin. Like samples on 55 occasions showed no bacteria in 27 instances; 1 bacteria in 10 cases; and only four of the samples showed more than 10 bacteria per cu. cm., the numbers in excess ranging from 13 to 62. Commenting on these figures Mr. Richert calls attention to the possibility of infection from the conduits, or from the air during aeration. He continues:

It is, therefore, deemed that if one sample of water is proved free from bacteria, the same may be said of the entire source as a whole. Consequently the deduction may be made, that the artificial ground water, flowing into the wells, has become perfectly sterile during its months of filtering. Such a result has never yet been obtained with an ordinary filtering basin.

The foregoing analytical results were based on analyses made by the city chemist prior to September, 1899. In a communication dated August, 1902, Mr. Richert gives some figures "taken from the annual reports of the water-works," but with no information regarding the dates or number of the analyses. They are as follows:

	River water.	Ground water. Artificial.	Ground water. Natural.
Temperature	32 to 72° F.	50 to 46° F.	48° F.
Bacteria per cu. cm.	100 to 10,000	0	0
Chlorine*	6 " 16	50 to 95	32 to 400
Ammonia ($N H_3$)*	0	0.0 " 0.8	0.4 " 5.0
Oxygen absorbed.*	3.4 to 4.0	0.8 " 1.3	0.6

*Mg. per liter.

The question naturally arises: How much of the water drawn from the wells comes from the filter basins and how much from the more adjacent water-bearing sand? Mr. Richert answers this question by stating that there is a difference of about 10% between the ground water level at the wells before and after they were put in use, and continues as follows:

As the supply of natural ground water, 528,000 gallons in 24 hours, corresponds with a pressure of 17.40 ft. (difference between ground-water and river levels.—Ed.) the 10% decrease of pressure represents a decrease of only 52,800 gallons, which may be totally disregarded. Every drop of the infiltered thus goes to the wells.

GENERAL CONSIDERATIONS.

In a pamphlet published in 1900, Mr. Richert sets forth in some detail his ideas regarding artificial underground water supplies. He first touches upon ordinary filter galleries, dependent upon either an adjacent stream or ground water, or both, for their yield, and mentions the well-known diminution of yield common to such sources. Unfiltered surface waters, he, in common with so many European engineers, apparently considers out of the question, and slow sand filtration of water from such sources, he says, "does not give the same absolute protection against epidemics as a rationally built ground-water-work." Recent advances in the knowledge of the flow of ground waters having placed their development on a scientific basis, the author considers ground water in all respects superior to other sources wherever it can be obtained in sufficient quantities. The yield of ground water depends, as is well known, on "the extent of the infiltration area and the geological nature of the underground strata. In the Scandinavian countries the conditions for ground water supplies are generally very unfavorable, owing largely to lack of permeable gathering grounds for rainfall. But "in many a valley there is under the clay cover a layer of sand or perhaps even of coarse gravel." In such cases it may be that the limited natural underground flow "could, under favorable conditions of infiltration, have yielded a far richer ground-water-stream." Therefore, "the engineer must assist nature with artificial infiltration."

The principle involved, Mr. Richert says, is old, but its applications, until the Gothenburg works were installed, had been only "on a small scale and under rather unfavorable conditions." At Wiesbaden and Remscheid water from brooks has been applied to open filter ditches, and at Chemnitz dirty water from the River Zwonitz is led partly to a filter canal and partly to a grassy field, being applied to the latter at intervals, as in sewage farming. In winter only the filter canal is used. The water is secured again by pumping it from wells, which, owing to the limited amount of permeable matter, are too near the points of applying the river water to give the best results.*

In 1888 Baurath Thiem projected a water supply for Stralsund "based on real ground water production." He proposed to lead water from a lake, by gravity, to five irrigation basins having a combined area of about nine acres, which would be supplemented, in winter, by a filter basin. The water was to have been collected in wells. The authorities did not adopt the scheme because they feared "the water would run off into the sand."

Later, Thiem proposed to develop water supplies by natural filtration through river beds, making use of but improving upon, an old method. He held that the failure of previous installations of this type was due to an insufficient knowledge of the velocity of the stream and the proper rate of infiltration through the stream bed. With just the right relation between stream velocity and infiltration the pores of the bed will be kept open, but if this is exceeded clogging will occur. The faster the current, the more rapid may be the infiltration.

Mr. Richert believes that filter basins like that at Gothenburg will give an undiminished yield for years. Observations of the variations in ground water level will show whether the rate of filtration is exceeding or falling below the yield of the wells, temporary overdrafts being possible on account of the water in storage, as it were, between the basins and the wells.

In a later discussion of this subject (dated August, 1902, and submitted to this Journal in manuscript form) Mr. Richert points out that by maintaining a sufficient head, or rate of filtration, ground waters of undesirable quality or infiltered water from a near-by foul river, may be excluded by a reversal of the natural ground water current.

Such confidence has Mr. Richert in artificial ground water supplies that he outlines a scheme for supplying London in this way. He proposes a series of filter basins, ten basins to each member of a series, each basin 328 × 656 ft., thus giving a total area of about 2,150,000 sq. ft. The basins would have their inner edges 3,281 ft. from the line of collecting wells, and the aggregate length of the line of basins, with spaces between, would be 13,124 ft. It is assumed that the underground stream of water from the basins to the wells would be 164 ft. deep, and that the volume of water would be 25% of the volume of sand. The cross-sectional area of the underground stream would therefore be,

$$13{,}120 \times 164 \times 0.25 = 538{,}00 \text{ sq. ft.}$$

The rate of filtration is supposed to be 3.28 ft. per day over the whole section, and therefore four times as great, or 13.12 ft. over the water section. This gives a capacity (in round numbers) of

$$538{,}000 \times 13 \times 7\tfrac{1}{2} = 53{,}000{,}000 \text{ gallons.}$$

The distance between the basins and the wells being 3,281 ft., and the assumed current velocity 13.12 ft. per day, it would take 250 days for the water to pass from the beds to the wells.

Mr. Richert states that the long period of flow between the basins and wells would partly balance variations between filtration and consumption, completely balance changes in temperature, and remove all bacterial and other impurities from the water.

*A much better account of the Chemnitz development may be found on pp. 107-10 of the third edition of Hazen's "Filtration of Public Water Supplies." We may also add that the yield of infiltration galleries at Denver, Colo., was increased in 1891 by the construction of basins having a combined area of 20 acres, over and near the galleries, and filling them with river water. The beds of the basins were scraped and plowed about once a year. See Eng. News, Feb. 1, 1894.

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Even the worm will turn, and the example of that long-suffering creature has recently been followed by the residents in New York city who have for many years been compelled to travel to and from their daily work under conditions not dissimilar to those encountered by the aforesaid worm when he becomes an unwilling occupant of a fisherman's bait-box.

Of course, street cars packed to the bursting point are nothing new in New York. Since a time when a Broadway omnibus was a symbol for congestion, the passenger traffic facilities in New York have always been inadequate to the demands. The horse car lines which succeeded the 'buses gave a temporary improvement, and another and greater relief was experienced when the elevated railways were put in service. By the middle of the '80's, however, the crowding of the elevated railway cars became a source of complaint, and it was only the transformation of the surface roads first to cable, and later to electric traction, that enabled the crowds to be handled in anything like satisfactory shape. Within the past year, however, conditions have again grown worse. The Manhattan Elevated lines carried more than 25,000,000 more passengers in 1902 than in 1901, the total for 1902 being 215,259,345. As long ago as 1889, these lines carried nearly 180,000,000 passengers, and while this rose to about 200,000,000 in the early '90's, the traffic fell back to the 180,000,000 figure with the improvement in the street surface lines, and remained about there until 1901.

New Yorkers have so long patiently submitted to the packing process, however, that a little more packing hardly counts, and we doubt not that everybody would have meekly made room, or tried to do so, for 25,000,000 additional passengers without increase in accommodations for them had it not been for the recent complete breakdown of the elevated railways on account of ice on the third rail. Human endurance has a limit, and when this happened the limit was reached. Since then commercial organizations, the press, and even the pulpit have been voicing public indignation over transportation conditions, and demanding that something be done, and that promptly for their remedy.

Very likely the agitation might have spent its force and accomplished nothing had it not been for the fortunate fact that the State Railroad Commission has the legal authority to compel the companies to afford relief, and that appeal was made to this body by the citizens. The Commission came to New York, held public hearings, made investigations, and on Jan. 2 took summary action, ordering the Manhattan Company to continue its "rush hour" train service from the beginning of the morning rush hour service until midnight of each day, and also to add to its equipment at least 100 cars a month during the months of January, February and March.

Concerning the latter part of this order, it may be said at once that if it is obeyed by the railroad company, it will be because the cars were already ordered months ago; for it is of course absurd to suppose that the railway company can buy cars as it would buy shelf hardware, or that it could secure any additional cars within the next three months unless their construction were already under way. It is not hazarding much to conjecture that the Commission was made aware that the railway company had new equipment soon to be delivered, and that its order was merely intended to hasten the completion of this and ensure its prompt entry into service when received.

Concerning the order requiring the continuance of rush-hour train service at all hours of the day, it is not quite clear whether the Commission means that trains of the same length as well as the same frequency must be run all day as are run in the rush hours. This would be a literal interpretation of its order; but such an order would be against reason and common sense. On the other hand, to give a frequent train service at all hours is necessary for public convenience as well as for the benefit of the railway's own treasury. An advantage of electric traction which has often been pointed out is that short trains can be economically run, and thus a frequent service maintained. Such a frequent service ought to be insisted on and rigidly required; but the length of the trains run need be no greater than is necessary to accommodate the passengers, and we mean "accommodate" by this and not the sort of "accommodation" which elevated passengers have hitherto suffered. Inasmuch as the public convenience can in no way be served by the running of empty trains, we have no doubt that the order will be enforced with common sense; and so long as the frequent train service is afforded, the length of the trains outside of rush hours need be no greater than is necessary to furnish seats to the passengers.

Besides the above noted changes in train service the Railway Commission ordered the Manhattan Co. to "take immediate steps to construct third tracks" on parts of its Second Ave., Third Ave., and Ninth Ave. lines, the total distance specified being about ten miles. As the company has already in use about 14½ miles of third track, and as the total length of the company's main lines is about 31 miles, it will be seen that the construction of this additional third track mileage will make the Manhattan a three-track system for about three-fourths of its extent.

Let us not be hasty, however, in assuming that the issue of this order by the Railway Commission will result in the construction of these additional tracks. A half dozen years ago the construction of additional third tracks on the elevated lines was under consideration by the Rapid Transit Commission and the Manhattan officers, and their need was as clearly perceived then as now. In its report made five years ago (Jan. 13, 1898), the Rapid Transit Commission said:

> The Board has thus far proceeded upon the assumption that it had no power to compel the Elevated Railway Company or any other railroad company operating within the city to extend its lines or to give [illegible] public facilities not required by its present charter [illegible] make sure, however, the committee has asked the opinion of the Board for an opinion upon the subject. The Board replied that the Board has no coercive power which, so far as they have been able to ascertain, [illegible] thority of the city has any such power; and that it is extremely doubtful whether there be constitutional power by new legislation to compel an existing corporation against its will to invest its funds in extension of its way or to accept and use a new railroad franchise.

If this legal opinion is sound, and we see no reason to doubt it, the Manhattan Co. can obey the third track order of the Railway Commission or not, as it pleases; that is to say, the construction of these additional third tracks will depend on whether the Manhattan Co. deems them a profitable venture. Of course there is no question that the additional traffic facilities gained would be worth far more to the company than the mere cost of building the additional structure and tracks. The city has contended, however, that the company should obtain a regular franchise for its third track extension instead of building it surreptitiously under the guise of switches and sidings as it has hitherto done. The officers of the company, on the other hand, having received so many valuable franchises from the city for nothing, have hitherto shown a large disinclination to pursue any more liberal course.

One fact which must not be overlooked in this connection, however, is the lease of the Manhattan lines to the company which is to operate the Rapid Transit system. There is reason to suppose that this change of control will result in a broader and better management of the elevated system, and in such co-operation with the city authorities as will result in the completion of the much needed third tracks.

Clay is one of the oldest of the materials with which the engineer works. No other material seems to have been used by man for constructive purposes at an earlier date than was clay. For long ages clay was a primary factor in the material and intellectual development of nations. It built huts, palaces and temples, and as it made possible the great cities of ancient times, the seats of national life, and supplied those early races with their books and records, so it also, through the crumbling of the unburned brick, hastened and helped the national decay. To-day clay has lost much of its ancient high position, but even so it barely yields first place, in either interest or intrinsic importance, to the newcomer—steel.

It seems curious that in spite of its use for ages past, we civilized and engineering peoples of today know little about clay, less, in fact, than about any other common material of construction. Disregarding the question of the geological history of clays, we really know little as to the properties of the substance. This statement applies more particularly to its relations to the civil engineer. In his various lines of work he everywhere encounters clay—and it usually brings trouble and uncertainty.

One reason for this state of affairs doubtless lies in the fact that the word "clay" covers a broad range of materials, generally similar but differing markedly in chemical and in physical constitution. The clay of the mineralogist may be a definite chemical compound, but in engineering practice clay may mean anything from kaolin to a semi-plastic mud consisting principally of fine sand or silt. Another reason for our ignorance regarding clay may be the variation in the physical state of the material as found in nature. Size and shape of grain, uniformity, moisture contained, and pressure to which the material has been subjected in the past, all operate to modify its behavior in puzzling manner.

Whatever the reasons, two things may be said: First, that much less is known about clay than about other constructive materials; and, second, that what has been learned about it has never been brought together (so far as we are aware) in a comprehensive manner. It may be doubted also, in view of the indefinite meaning of the term clay as the engineer uses it, whether this want for a book on "Clay In Engineering Construction," will be filled in the near future.

We would claim special interest, in this connection, for Mr. Cambie's note on a property of clay, as reprinted on another page. It tells of

certain landslides which were chargeable to clay and apparently also to irrigation). The matter of landslides is one of those referred to above as being (to the civil engineer) troublesome manifestations of the uncertainty of clay. It is highly desirable that information regarding the observed phenomena of clay and engineers' experiences with the vagaries of the material be collected, and the note of Mr. Cambie is one contribution to such a collection.

It is a pity that a paper so well edited as the New York "Sun" should make such a misleading statement regarding water filtration as appeared in its issue of Dec. 28. In the course of a long and generally satisfactory editorial on "Typhoid Fever," the "Sun" said:

> The removal of certain organic and inorganic elements is assured by filtration, but this process is not reliable in the elimination of infective organisms. While it may be impossible, as modern communities exist, for the authorities to furnish a germless supply of water, they should diligently endeavor to prevent the pollution of the watersheds from which the supply is derived.

Fifteen years ago there was some excuse for saying that filtration could not be relied upon for the removal of disease germs, but in the intervening years bacteriologists and engineers have demonstrated the contrary so conclusively that few of either profession hesitate to recommend a filtered water supply whenever it can be secured at a cost decidedly lower than so-called naturally pure water. In Germany, surface water supplies are virtually prohibited unless subjected to filtration, and it is obvious to anyone at all familiar with the facts that it is becoming more and more difficult in all settled portions of the United States to secure a gathering ground for a surface water supply that is not liable to more or less pollution. Household filters, except for one or two comparatively expensive types, attended with the utmost care, are most certainly not reliable, and while of course we would all prefer a water supply guaranteed to be naturally pure to one requiring any sort of treatment to render it safe, there are many localities where such a guarantee is impossible or at least impracticable, in which event one may turn to filtration without any anxiety as to the results. If it were otherwise what could be said of the $15,000,000 or so being expended at Philadelphia for filtration works; of the bids now being invited for a large filtration plant for our national capital; of the proposed filter plants for Cincinnati, .New Orleans and Pittsburg; of those under construction at Providence, Louisville and elsewhere; and of such fine filtration systems as are now supplying water to Albany, Lawrence, Paterson, Mount Vernon, and scores of other American cities and towns, to say nothing of London, Berlin, and other European cities?

An interesting piece of news from England is the sale of the municipal telephone system at Tunbridge Wells to the National Telephone Co., with the approval of the British Postmaster-General. The conditions of the business of telephony in England are quite different from those in America. Here the field is largely controlled by one great corporation, with a strong and growing competition of independent companies in many districts. Both the Bell and the independent companies, however, are entirely private enterprises; moreover, they are subject to little or no governmental regulation or control. The same holds true for telegraphic communication. In England, on the other hand, the government controls and operates (with the exception of ocean cable lines) all telegraphic communication, the control being vested in the Post-Office. The business of telephony is similarly controlled, but the larger part of it is licensed to the National Telephone Co., and some other smaller companies. In London, the Post-Office operates an extensive telephone system, but this is worked so as to exchange with the National Telephone Co. In recent years there has been a widespread movement for municipal telephone systems, in general sympathy with the sentiment for municipal operation in other fields. The Tunbridge Wells telephone system was the first municipal telephone system established; it commenced operation in July, 1901. Glasgow followed, opening its system in August of the same year, with as many as 5,000 subscribers. Licenses have been granted to several other cities, and a number of further applications are before the Post-Office.

As to the working of these municipal telephone exchanges, the present sale at Tunbridge Wells would seem to indicate failure. However, the British "Municipal Year Book" for 1902 states, in regard to this system, that "an independent investigation into the financial position of the municipal telephone undertaking (in Tunbridge Wells), conducted in December, 1901, by the borough accountant, showed that it was entirely self-supporting." It appears that the National Telephone Co. reduced its rate at Tunbridge Wells by fully one-half to compete with the municipal system, and there was no exchange or other arrangement between the two systems. At Glasgow, the company is not undertaking such sharp competition, due to a right-of-way provision which would compel the company to also reduce the rate in certain other towns. The Glasgow municipal system is therefore able to give efficient service at rates lower than those of the company, and records a complete success up to the present.

The general drift in England at present seems to be toward ultimate government ownership and operation of the entire telephone service. It should be remarked that the license of the National Telephone Co. expires in 1911, except that wherever competitive licenses have been granted expiring at a later date the company's license continues locally until the same date. At the expiration of the company's license the government may purchase such portions of the plant as it considers suitable. There seems to be every probability that in this way the government will ultimately obtain control of the telephone business all over England. Up to the present the outlook had been that in the meantime many municipal undertakings would be established for the purpose of giving lower rates and better service than could be obtained from the company; and the initial success at Glasgow and at Tunbridge Wells had strengthened this promise. The situation in England in regard to municipal telephony seems very much like that under which the independent telephone movement has developed in the United States. If we can believe the British "Municipal Year Book" (1902) the past results indicate that "given efficient service, low charges, plus a certain amount of civic patriotism, municipal undertakings are soon in a stronger position than the local undertakings of the company;" and this may be applied to the independent movement here if to the words "efficient service" we add "a disposition to accommodate the public."

The virtual failure of the Tunbridge Wells system (for its sale must be interpreted as such), does not make the above untrue; but it will doubtless tend to somewhat discourage municipal enterprise in the telephone field in England. So-called "municipal trading" in England is having a hard time of it lately, anyway, being attacked by interests of all sorts, mainly vested interests which are directly threatened with municipal competition. In connection with the Tunbridge Wells sale, the municipal advocate may take some comfort, however, from the fact that, in authorizing the sale, the Postmaster-General has made stipulations which assure a telephone service in Tunbridge Wells cheaper and better than existed before the municipality entered the field; moreover, though the latter's license ran intil 1925, the Postmaster-General has limited the duration of the license of the consolidated undertaking to the regular period of 1911.

The hygienic qualities of well-chosen ground water supplies have long been known and likewise their frequent limited capacity. We, therefore, bespeak careful attention to the article, elsewhere in this issue, on an "Artificial Underground Water Supply at Göthenburg, Sweden," developed by Mr. J. Gustaf Richert, an engineer of Stockholm. The article also includes an abstract of a general discussion of the subject by Mr. Richert. The plan is simple enough. Ordinary wells are sunk in water-bearing sand of limited yield and some hundred or thousand feet away large basins, with natural sides and bottoms, are excavated in the same water-bearing area. Surface water from some abundant but otherwise undesirable source is continuously delivered into the basins, and after many months the yield of the wells is materially increased. When the loss of head in the filter basins becomes too great it is reduced by drawing off the water and cleaning the sand bottoms, just as in ordinary filter bed practice. The plan certainly merits attention, but Mr. Richert seems to have overestimated its possibilities, at least in the case of his estimates for developing a supply in this manner for all of Greater London. It is also probable that, even allowing for recent increases in the knowledge of the laws governing underground water movements, the yields to be obtained under various local conditions would often be problematical.

AN ATTEMPTED DEFENCE OF THE ELECTRIC SMELTING OF IRON ORES.

In our issue of May 2, 1901, we showed that, assuming no loss of heat energy whatever, it would require 131 E. HP. days (of 24 hours each) to produce a net ton of iron from a 65% ore. This was upon the assumption of a theoretically perfect furnace.

In our issue of Oct. 2 it was stated that in actual practice in Sweden, 362 E. HP. days (24 hours) had been required to produce one ton of iron.

In the "Iron Age" of Dec. 11, 1902, it is stated that the firm of Keller, Leleux & Co. have a plant at Kerrousse, France, where, with a 375 HP. electric furnace, they have produced a metric ton (2,204 lbs.) of steel with an expenditure of 2,800 KW. hours, which is equivalent to 104 E. HP. days (24 hours) per metric ton of steel produced.

This latter claim, it is self-evident, is made either in ignorance, or with intent to deceive, since such an efficiency is impossible of attainment in a theoretically perfect furnace, with absolutely no loss of energy.

In the "Iron Age" of Nov. 20, 1902, we find a paper by Mr. A. J. Rossi of New York, discussing the general feasibility of electric iron smelting and attempting to show that the process can be made commercially successful. Mr. Rossi has been for some time engaged in operating an electric furnace working on the reduction of titanium iron ores in the Adirondacks. He states that in an actual run of ten weeks his company obtained average results amounting to 200 E. HP. day (24 hours) per gross ton (2,240 lbs.) of metal produced. This, it will be observed, is about 50% more electricity than we allowed for a theoretically perfect reduction from a very high grade ore. If Mr. Rossi secured this result, we should say he did exceedingly well. Allowing for necessary losses at each stage of the process there is no reason to suppose that very much higher efficiency than this can be attained in the most perfect electric furnace that can be devised.

Apparently Mr. Rossi's results are good testimony to the correctness of our own computations as well as to the soundness of our position that it is impossible for any possible electric smelting process to compete with the blast furnace in reducing iron ore. Nevertheless, with a courage worthy of a better cause, Mr. Rossi attempts to show that on the basis fixed by his own experience the electric process has a chance commercially, and to prove it he makes the following comparative estimate:

Cost of Manufacture of 1 Ton of Pig Iron by Blast Furnace.

1.66 tons iron ore at $4.50	$7.47
1 ton coke at $2.50	2.50
½ ton limestone at $1	.50
Labor, etc	2.00
Total	12.47

Cost of Manufacture of 1 Ton of Pig Iron by Electric Furnace.

1.66 tons iron ore at 75 cts.	$1.25
0.32 ton carbon for reduction at $1.25	.40
½ ton limestone at $1	.50
Labor	2.00
Wear of electrodes	2.50
Electricity (200 E. HP. days per ton pig) at $10 per E. HP. per annum	5.50
Total	12.15

The reader will note that it is supposed to cost blast furnace men $4.50 a ton for ore, whereas their electric furnace competitors will develop

new mines by a marvelous system that will enable them to mine, haul, and deliver ore for 75 cts. a ton to the furnace mouth—if the electric furnace has a mouth. It is also worth noting that "carbon" is assumed to be only about half as costly as coke.

The main point in the above calculation which is worth attention, however, is the assumed cost of $10 per year for one horse-power of electric current delivered night and day continuously, week in and week out. There may possibly be a few favored spots where water power can be developed, converted to electric energy and sold at a fair profit for the low figure of $10 per electric HP. per annum; but we are strongly of the opinion that such favored spots are extremely rare. It must be remembered in discussing this figure, that contracts made by a water power development company which, having expended large sums on its plant, has to sell its power at some price or become bankrupt, are not a fair criterion of the cost of water power. In estimating this cost, not only must the interest on the cost of installation be included but also the cost of repairs, supplies and operation, and besides this the annual depreciation. The last is not by any means so small an item as is commonly supposed.

However, let us assume for the sake of argument that all Mr. Rossi's figures were correct, and that his comparison which puts the cost of electric furnace iron and blast furnace iron practically on a parity were sound; there is still a consideration which puts the electric process quite out of the running. This is the relative investment required for the two processes. A complete blast furnace plant producing 350 tons of iron per day can be erected at a cost which we may put in round numbers at $1,000,000. An electric furnace plant to produce a similar amount will require a water power electric plant with a capacity of at least 60,000 HP. We need hardly say that the only location on this continent where such large amounts of water power have been developed are at Niagara and Sault Ste. Marie, and the cost of a plant of such a capacity could hardly fall below five or six million dollars. In an industry subject to such ups and downs as the iron industry, the fact that one process requires five or six times as large an investment as the other would be sufficient to put it out of the question as a commercial competitor.

As a final word, we may note that Mr. Rossi's electric iron is to cost $12.15 per ton at the furnace, with all the advantage of electric current at $10 per E. HP. per annum, ore at 75 cts. per ton and "carbon" at $1.25 per ton. Now it is well known that the ordinary blast furnace has produced iron at costs as low as $6 to $8 per ton. By Mr. Rossi's own figures, then, our position that the electric furnace cannot compete with the blast furnace is substantiated.

LETTERS TO THE EDITOR.

Some Good Things Regarding Discipline.

Sir: Mr. A. M. Fisher, of the New York Railroad Club, presented a paper on "Efficient Discipline" to the Club at its meeting of Nov. 21 (when that subject was the topic of the meeting) which I believe is worthy of more extensive publication than is possible in the Proceedings of the Club. Happily the author has expressed his views according to the formula of Mr. Seymour Eaton in presenting the first number of his "Book-lover's Magazine": "Most people can say their best on any topic in three or four hundred words; to go beyond this is either to repeat or to pad," and is for that reason likely to be of interest to your readers, as well as for the importance of the topic. It is the following:

Discipline implies discipleship, and that constancy. Discipline, to be efficient, must not tend all in one direction; that is, it must not emanate only from an official toward an employee—many times it must come from an employee to a superior in the way of suggestions. To foster this mutuality of discipline, employees must be imbued with the idea that they are working *with* not *for* a superior.

Being an efficient disciplinarian implies that the individual has a thorough knowledge of matters entrusted to him ,and that he is a good judge of motives. He must expect men to make mistakes, but motives must determine whether discipline shall be punitive or corrective.

An efficient disciplinarian is very careful in the use of the word "why," for by frequent use it degenerates into "whine," and a man who whines courts disloyalty—the greatest foe of efficient discipline. Freedom from jealousy, or from fear of being outdone, is a winning factor in accomplishing efficient discipline.

Yours respectfully, John I. Riegel.

Scranton, Pa., Dec. 27, 1902.

Tile Underdrainage as a Relief from Seepage Water Due to Irrigation.

Sir: Replying to the inquiry in Engineering News of Dec. 25, 1902, about the drainage of irrigated towns: Greeley, Colo., is an example of relief from seepage water being afforded by tile drainage. About fifteen years ago construction of a reservoir for irrigation on the higher lands west of the town and the watering of the farms below it caused a rise of the ground water in Greeley, filling the cellars, submerging some of the gardens, threatening the lives of the trees and the health of the people. Underdrainage afforded immediate and permanent relief. The same result followed the underdrainage of part of the Agricultural College farm at Ft. Collins, Colo.

Respectfully, Elwood Mead,
Chief of Irrigation Investigations.

U. S. Department of Agriculture.
Washington, D. C., Dec. 27, 1902.

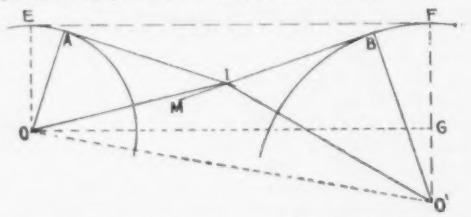
Sir: In answer to the inquiry of "Citizen" in your issue of Dec. 15, 1902, it may be said that the trouble from the rise of ground water due to seepage is common in the irrigated districts, and in some cases has been sufficient to flood cellars or to prevent their construction. In those cases tile draining has proved beneficial as in other cases of saturated soil. Numerous towns have drained to some extent. The cases of Greeley and Fort Collins, Colo., may be mentioned specifically. In some cases the drainage has been accomplished by the means of sewer lines laid with open joints. The result has been, however, a lowering of the ground water when a suitable opportunity for discharge was presented. Drainage in cases of seeped or alkalied ground has also been frequently done. One of the first drains of such character was laid on the grounds of the Colorado Agricultural College in 1888, and brought a tract of seeped and alkalied ground, producing nothing but cat-tails, into one of the best portions of the farm.

L. G. Carpenter,
Professor of Irrigation Engineering.

State Agricultural College, Fort Collins, Colo.,
Dec. 27, 1902.

Some Remarks About Joining Two Curves with a Tangent

Sir: In your issue of Dec. 18, 1902, you published a letter from Mr. E. H. Beckler giving another solution of the problem of joining two curves by a common tangent. I consider Mr. Beckler's method open to the same objection as the method given in a well-known field book, in that in actual field work it requires the finding of the intersection of a straight line and a curve. Since the solution calls for the turning of a tangent at the point of intersection, it is evident that the intersection with the actual arc of the curve must be found. It was to avoid that problem that I used two tangents in my solution published by you in your issue of Nov. 6, 1902.



The solution which I gave may be applied where the intersection must be inside of the required tangent (see accompanying figure) by simply changing the angle M I A in equation (5) of my demonstration already referred to to a positive instead of a negative value; making equation (5) read $O\,I\,O' = 180° + M\,I\,A - (A\,I\,O + B\,I\,O')$. Equation (11) will then become $E\,O\,O' = E\,O\,G + G\,O\,O'$ both known angles; and equation (12) becomes $A\,O\,E = E\,O\,O' - (A\,O\,I + I\,O\,O')$, both known angles.

As the other equations of the method are simply the solution of triangles, it is obviously unnecessary to change them.

Yours truly,
C. W. Baldridge.

Div. Engr.'s Office, C. & N. W. Ry, Winona, Minn.
Dec. 30, 1902.

Current Water Wheels Used on the Snake River, Idaho.

Sir: In reply to the inquiry by J. W. S. about developing power in the current of a stream by means of a water wheel mounted on a float, I would say that he will not have to go far from home to see machines of that sort in operation. During the irrigation season there are a number working in the Snake River and Clearwater River. Here at Lewiston there are two working each summer, not three miles from my office.

The ranchers themselves built them without any rules. The writer designed one last summer for a client who was going to put it in the Snake River to raise water for a mining camp. It will require two barges placed at a specified distance apart, or rather, as one rancher said, "It is a double-hulled boat," for the deck extends across the ends like a platform. The space between the hulls must be proportioned like a mill race, so there will be about one square foot of area for each 85 or 90 cu. ft. per minute flowing through. This area assumes the depth as being the submerged depth of the floats. The wheel should not be less than 12 or 14 ft. in diameter, and 16 ft. is a large wheel. About ten floats is a proper number. The number of floats should be such that when one is submerged its full calculated depth, the floats on each side of it will be slightly in the water. The floats should be at least 18 ins. wide and be submerged about 12 ins.

The horse-power of the floating mill may be ascertained by the following rule, in which

V = velocity of stream ft. per sec.
C = the emciency = 4-10.
B = width in ft. of the floats in the water.
A = depth in ft. of the floats in the water.

$HP. = .0018\,A\,B\,C\,V^4 = .0072\,A\,B\,V^3$.

Some gearing will have to be used to transmit power at any reasonable speed. They are more suitable for pumping than for any other purpose. They must be very strongly anchored and during time of high water are generally moored close to shore for protection from floating trees. During the winter they are kept close to shore to protect them from floating ice.

J. W. S. will find much useful information about floating mills in "Motive Powers and their Practical Selection," by Bolton, to which work the writer is indebted for the information he first obtained on this subject some six years or more ago.

Yours truly, Ernest McCullough.

Adams Block, Lewiston, Idaho, Dec. 13, 1902.

Compensation of Doctors and of Engineers.

Sir: While your correspondents L. C. H. and A. T. E. are discussing the question of compensation of engineers and doctors, why not touch on the interesting question of the poor physician before he is forced to enter the engineer corps to be criticised by those who do not fully understand his miserable plight. His case, even before he comes in contact with the A. T. E.'s, if you look at it closely, which nobody seems inclined to do, is truly a very, very lamentable one. Think of this: A rich man who has made his millions, by fair means or else by hook or by crook, it does not matter, feels that he has done nearly enough for this world, and that some of his thoughts and deeds might be reasonably employed now to do something towards securing dividends in another world possibly to come. The recipe for the cure of such morbid anxieties is an old and hackneyed one; no necessity for breaking one's head, as he had done before on Wall Street matters, or about engineering enterprises in the West. Oh, no! There is a panacea; let's found a hospital, or if we are very high-toned, let us endow a college. The hospital staff is filled by the founder's beneficiaries, or perhaps such of his friends, especially such as are willing to contribute more influence and more money for the institution. To the clinics of this hospital only the poor are supposed to go. Such as appear there and are not poor are treated also and pay a monthly fee. We may naturally expect that some of the staff physicians, who, be it understood, receive no pay, as they are simply helping the rich man in a friendly way to pay his debt to heaven and his conscience, will divert some of the latter patients to consult him in his own office. But what becomes of the poor physician, the general practitioner of the community while so much good is being done around him. He has to eke out his existence, support his wife and children with what these good charitable people have left him. Only some of the very poor are left to him, and these without public condemnation and a kind of dishonor he cannot refuse, in case of urgency, to treat gratis pro Deo. The poor physician is not so perplexed as the rich man may have been before beginning his great charitable career as to the means of insuring to himself a livelihood in heaven, but he would be very much pleased if the admirable philanthropy of others allowed him to make one in this vale of tears.

I cannot help making here two remarks, which seem to me exceedingly curious, and I believe that anybody with a tolerable modicum of humor in him much be struck by their piquancy: First, the anxiety of doing good is sometimes so great that the thing is monstrously overdone. What will you say of a hospital intended for 700 patients that can recruit only 35? But now comes the second point: In order to come as near as possible to the number of patients which their colossal structure requires they have the unspeakable naivete to send around inviting the poor physician whom they have already despoiled to help them complete the spoilation by sending to the hospital clinic the few poor patients who have been left to him. The man in the hospital, whose specialty it is to care for a certain fraction or a certain casualty of the human body, wants the poor physician to send him all those of his patients (if this way of speaking is not ridiculously grandiloquent) who are affected with the complaint to which he has devoted his genius. Another who has a different specialty makes a similar request. They want their clinics to be well attended and interesting, whatever the poor doctor's dinner may be. For, you see, the rich man must read reports which show that his work is prospering on earth, as is his spiritual wheat in heaven.

Albert S. Ashmead, M. D.

333 W. 23d St., New York, Jan. 1, 1903.

A Pro-Metric Argument.

Sir: When the writer studied arithmetic, some thirty years ago, three barleycorns made an inch. Whether it is still taught that the barleycorn is the base of our system of measures of length the writer is unable to say; however, it is the original base, and the suspicion is forced upon one that the originator was under the influence of a distillation of the fermented extract of barleycorn when he evolved a system with such a base, or that the mythical personage, John Barleycorn himself, was its father.

Our system of measures of length has three distinct units, the inch, the foot and the yard, not to mention the rod, furlong, mile, league or surveyor's chain.

By your own admission (p. 501, Engineering News, Dec. 11, 1902) the chemist and the electrical engineer have practically adopted the metric system of weights and measures, but the civil engineer continues to struggle with inches, feet and yards, though he has made for himself a decimal chain and level rod. Now, may I ask, how much longer has he to wrestle with this trinity of units, that the mechanical engineer may preserve the expression of his standards in inches and vulgar fractions thereof?

Every civil engineer who has read Mr. Halsey's paper and your editorial comments thereon has doubtless recalled the labor he has expended on calculations requiring the employment of feet and decimals, and the dreary necessity of stating his results in feet, inches and vulgar fractions of an inch, when, had he employed the metric system, his results could have been stated directly in the single unit employed in his calculations. It seems hardly possible that any engineer who has been through the mill can advocate the retention of our present system.

It may be urged in defense of our hybrid system that the base of the metric is practically an arbitrary one, and that we have tables for converting inches into decimals of a foot, and vice versa; nevertheless, the base of the metric system is far more scientific than ours of the barleycorn, and a system that permits results to be stated directly from calculations is far more economical of both time and labor, and involves less probability of error than one requiring the consultation of tables.

As to the acquiescence of the people in any legislative enactment requiring the substitution of the metric system of weights and measures for the one now in use, it is only necessary to call to mind the similar legislative action substituting a decimal system of currency for the irrational English system. The people took kindly to the change, and the pursuit is none the less earnest now that we are chasing down the dollars, dimes and cents instead of pounds, shillings and pence.

Very respectfully, D. M. Andrews.

Lincoln, Ala., Dec. 26, 1902.

Have the "Plain People" Anything to Say About the Metric System?

Sir: I was much surprised to read the following sentiment in the article "For the Metric System," in p. 541 of your issue of Dec. 25, 1902, and signed C. S., Washington, D. C.:

> Neither the keeper of a store with various standard articles nor the mechanic who works at their manufacture have anything to do with these questions.

It is hard to believe that such is the opinion of any rational being. If Mr. C. S. is from one of the Government bureaus it would perhaps be well to remind him, as the Quaker reminded the pompous justice who insulted Wm. Penn: "My friend, this man" (storekeepers and mechanics) "makes such things as thou art."

The people at large pay their public servants, and have a right not to beg, but to demand that their results be placed in measures that are understood. They have the right to demand that the past records of this nation should not be made sealed books to their children because some computer wants a new logarithmic table.

If we employ a typewriter we do not hire him to write Choctaw or Sanscrit because he likes it best, nor yet that the Austrians may read it. But he is employed to write so that his employer may read it.

If during a lifetime a physician discovers one new fact he becomes famous; if he discovers two, that fame will be immortal; but we fail to see any force in an argument which would compel not simply the few interested, but a whole nation to learn his methods of calculation in order that he may place the decimal point in another position while his brain is running riot with speculation.

The storekeeper and mechanic sneered at by Mr. C. S. form the great majority of the people who do use measures and weights, and all of the calculations made by all of the poor overburdened computers and physicists of the world would not be worth the lead worn from their pencils did not the mechanic exist to transform their results into machines, and the storekeeper to distribute them.

What earthly good would it be to us to know the elastic force of steam had we no mechanic to make an engine and no salesman to sell it—ergo, no purchaser.

In keeping with the cry for universal weights and measures, let Congress show how perfectly helpless it is by passing a law that from and after Jan. 1, 1904, the only legal language to use in the United States shall be Volapuk, for certainly a universal language is a greater desideratum than the other which would necessarily follow.

It would be a far more sensible act if it would repeal all legislation of any kind whatever legalizing the metric system—"the national characteristic of the only nation that ever officially denied the Divine existence."

Yours truly, C. H. T.

Buffalo, N. Y., Dec. 29, 1902.

The Metric System Legislation and the American Society of Mechanical Engineers.

Sir: There is method in the madness of the metricists. Under existing laws every citizen of the United States enjoys entire freedom of choice between the English and the French systems of linear measurement. It is evident that further legislation on this point can serve no purpose at all, unless it be in some way to restrict this freedom.

With a duplicity that needs to be exposed, the metricists have introduced a bill into Congress which has been favorably reported by the House Committee on Coinage, Weights and Measures, and is in danger of becoming a law, which makes the metric system THE legal system in this country, and requires its use in the government departments.

This bill has been drawn with great astuteness. It imposes no penalty. If it had done so, its real character would have appeared. Now its advocates say that it is not compulsory; no one need obey it unless he chooses to. In the "American Machinist" of this week Mr. F. E. Drake describes it as *authorizing* the use of the metric system. But its promoters must know that the word "the" is exclusive, and any other system is made illegal. That is what it was put there for. The whole animus of the bill is shown in this word.

The next step is to muzzle the Society of Mechanical Engineers. This Society must not express an opinion between conflicting systems. It must not take sides with either party. To do so would be an intolerable violation of its principles. It must maintain entire impartiality. If they can fool the Society into silence, then their way is clear. They will say to Congress: "Even this great representative Society, where, if anywhere, opposition is to be looked for, will not express an adverse opinion." Indeed there would be nothing to prevent their going further, and claiming that its members were almost unanimously in favor of the measure.

Do its members realize the false position in which the Society is even now placed, and that, unless its voice in opposition to it shall be heard in trumpet tones, it will be represented as assenting to this bill?

Do they realize that its promoters are asking Congress to take sides with *them*, thus releasing the Society from any obligation to impartial silence? Do they realize that the Society has a right to speak out, and that it must speak out, or submit to any degree of misrepresentation?

The committee of the Society felt it its duty to go to the bottom of the matter, and set the two systems side by side, so that the opposition of the Society to this measure might be most effectively exerted. They have not grounded this opposition on the unspeakable confusion and loss, beyond any power to estimate, which would be caused by the passage of this bill, although that would be reason enough to warrant it. They have taken the fundamental ground that, so far as linear measurement is concerned, the change would be to an inferior system, that the attachment of all English-speaking races to our system is warranted by its superiority, and have endeavored to make this superiority manifest. They look confidently for an overwhelming support in their position.

Chas. T. Porter.

Montclair, N. J., Dec. 24, 1902.

WOODEN-BRACED ARCH HIGHWAY BRIDGE AT ST. PAUL, MINN. Designed by A. Munster, M. Am. Soc. C. E.

A Wooden Braced Arch Highway Bridge at St. Paul Minn.

Sir: The enclosed photographs of a trussed circular arch highway bridge may be of some interest. This bridge is situated near the west bank of the Mississippi River on the Mendota road, about one mile west of St. Paul. With the exception of the bolts and tie rods at the panel points the truss is built entirely of wood. It has a span of 190 ft. and is supported on small masonry abutments. This style of structure was chosen principally from an artistic a trestle for this location. It was built in 1889 from a design by Mr. A. Munster, M. Am. Soc. C. E., of St. Paul.

E. M. Grime,
Asst. Engr. C. G. W. Ry.

1709 7th St, So.. Minneapolis, Minn., Dec. 8, 1902.

Notes and Queries.

F. H. C., Philadelphia, asks for data as to the friction between mercury and surfaces of iron and of glass.

Mr. J. D. Lowell, C. E., of Chelan, Wash., wishes to know where he can obtain information on bituminized paper water pipes.

O. H. T., Rockland, Me., writes:

> Possibly some readers using "Vandyke" print paper may be interested to know that Collins' "Ink Eradicator" will remove any line from the prints very readily. This may be generally known, but I only discovered it for myself a few weeks ago.

An error was made in the article describing the Rowe system for burning powdered coal, published in our issue of Dec. 25, 1902, by stating that this system had been installed at the power plant of the Indianapolis Water Co. The system for burning coal dust at this plant has been designed by Mr. L. K. Davis, and the work done by the C. O. Bartlett & Snow Co. was simply to furnish one of their standard driers and to build, from Mr. Davis' plans, bins, elevators, etc. We are indebted to Mr. Davis and to the C. O. Bartlett & Snow Co. for the correction of this error.

A NEW WAGON ROAD is being built by the Government of Hondurus, from San Lorenzo on the Gulf of Fonseca, on the Pacific Coast, to Tegucigalpa, the capital city, a total distance of about 81 miles. The road has been completed for half the distance to the coast. The new road runs over fairly level ground, the maximum grade being 6%, and for most of the distance varying between 2 and 4%. As soon as the road is completed to the coast, it is intended to utilize one side of it for a trolley line for freight and passenger service, there being an abundance of water power at hand for supplying electric current.

AN UNRECORDED PROPERTY OF CLAY AND IRRIGATION AS A CAUSE OF LANDSLIDES.*

By H. J. Cambie,† M. Can. Soc. C. E.

Some years ago the writer found that ordinary clay, such as used in the manufacture of bricks, and commonly spoken of as plastic clay, would, if dried sufficiently to remove nearly all its moisture, lose its cohesive properties, and would, if water were afterwards applied to it in considerable quantities, become an almost liquid mud. On the other hand, clay which has not been so dried will not absorb any more water, and will lose only some of its outside particles in the washing. The writer has been unable to find any reference to this property of the material in question in the text-books at his disposal.

It came to his notice under the following circumstances: The main line of the Canadian Pacific Ry. runs for nearly 150 miles through a portion of British Columbia, situated between the eastern slope of the Cascade Range and the western slope of the Gold Range. There is no regular rainfall over this area, and crops cannot be grown without irrigation. A good many thunderstorms do occur in the summer, but only over very limited areas, and the rainfall from them runs away quickly without soaking into the ground to more than a depth of one or two inches, and is dried off in a few hours by the rapid evaporation incident to the region. These characteristics are especially pronounced in the central part of the area mentioned. The farming lands are situated on benches, sometimes 200 ft. or more above the level of the railway, which runs along the valley of the Thompson River, and at no great distance from the bank. Hay is the most valuable crop raised, and is used to winter cattle; with sufficient irrigation, several crops of it can be obtained in each season. Water has, therefore, been lavished upon the fields for nearly forty years, and has, in the opinion of the writer, been the cause of numerous landslides, one of the greatest of which occurred in 1881, when about 100 acres slid forward for nearly a quarter of a mile, falling in that distance about 300 ft., and completely blocking the Thompson River for about three days by forming a dam 75 ft. or more in height. Many similar slides on a smaller scale have occurred since that date, but generally with slower movement and less disastrous effect. One of these is of large area and includes a portion of the railway line; it has required constant watching and has been a cause of much anxiety to the railroad officials, because, although its forward progress has been slow, it has begun to move, year after year, at a date about three months after the beginning of the irrigation season, and has continued moving for about the same period of time. In 1886 the Canadian Pacific Ry. Co. took legal proceedings against the parties irrigating the fields above this slide, and it devolved upon the writer to furnish the legal advisers for the company with evidence to prove that the slide was due to the action of irrigation water. An investigation was made by the writer in consultation with Messrs. Stanton and Schuyler, who were employed by the company as experts in hydraulic engineering and particularly in irrigation practice, and with Mr. H. J. Warsap, manager of the Canadian Pacific Ry. Portland Cement Works at Vancouver, an expert in clays. At the slides were found beds of clay so exceedingly dry and hard as to have the appearance of soft sandstone, and still retaining the marks of picks in the slopes of railway cuttings, where dressed many years ago. When a block of this dry indurated clay was placed in a soup plate and water dropped upon it, the clay absorbed 50% of its own weight without any change of form or other visible effect, but when it had absorbed about 60% of water, its structure completely collapsed, and it became as fluid as water. This was considered by us as conclusive evidence that the irrigation water which had been poured for weeks and months on these beds of clay had been the cause of the slide; but in court this argument was met by a demand from the opposing counsel to be told why the bluffs of this material, which were washed at their base by the river, did not disintegrate and slide. Several ingenious theories were offered to account for this, but were not convincing. The writer now thinks that it was because these bluffs had never been dried out below high-water mark, and the material in them, therefore, did not possess the property of soaking up water and of finally collapsing. In all probability the jury was influenced by the evidence that no slides had occurred before the commencement of irrigation, and that there was irrigated land in the rear of each slide.

A year or more after the trial the writer, while experimenting with Mr. Warsap on some clay which had been dried for other purposes, found that it gave the very same results as the dry clay from the interior of the Province. This led to experiments with other clays, and it was found that they all lost their cohesive properties when the moisture was removed.

It is probable that this property of clay has been the cause of many of the landslides which have occurred this year in the valley of the Oldman and Belly Rivers, between Medicine Hat and the Crow's Nest Pass, for there has been an exceedingly heavy rainfall over these valleys during the year for the first time since they have become known.

*A paper read before the Canadian Society of Civil Engineers, Dec. 4, 1902.

†Vancouver, B. C.

TRACK ELEVATION IN CHICAGO is only about half completed, according to the annual report of Mr. John O'Neill, Superintendent of Track Elevation. During the ten years which have elapsed since the work was first commenced, ordinances have been passed calling for the elevation of 122 miles of main tracks and 630 miles of other tracks, together with the construction of 513 subways. The total estimated cost is $33,463,250. The work thus far accomplished includes 68 miles of main tracks, 338 miles of other tracks, and 251 subways, at a total cost of $22,080,000. Mr. O'Neill estimates that while in 1891, deaths due to railway accidents represented 21% of all deaths by accident in the city, the proportion in 1901 was only 14%. During 1902 the work done has amounted to 7.77 miles of main tracks, 30.75 miles of other tracks, and 32 subways, representing a total cost of $3,000,000. Four ordinances were passed by the city and accepted by the railway companies. These provide for elevating 28.65 miles of main tracks, 165.45 miles of other tracks, and the elimination of 90 grade crossings, at a total cost of $7,775,000. One of these ordinances covers the elevation of tracks and separation of railway grades at Grand Crossing.

DUSTLESS REFUSE HANDLING is practiced in the city of Berlin, Germany. The dry refuse is collected in covered iron carts, which are water and dust tight. The metal collection receptacles are emptied into these by way of a closed chamber in such a way that no dust can escape into the street. The problem solved most recently was the dustless dumping of the carts into the railway cars by which the refuse is carried to the destructors. The loading station built for this purpose has two rooms, an upper one into which the carts are driven, and a lower one into which the railway cars are run. Both rooms have tight doors, which are opened only to run the wagons in or out. A dumping chute from the upper to the lower room is provided, the chute being enclosed on all sides. When a cart is to be dumped, which is done through gates in the floor of the cart, a hood is placed, which forms a tight enclosure from the cart to the upper end of the chute, so that the dust is to a great extent prevented from spreading into the room. When a railway car is fully loaded, it is covered with tarpaulins to prevent dust blowing off in transit. This method of handling, which is reported very successful, was worked out by the "Staubschutz" Co., of Berlin.

WASHINGTON MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The 52d annual meeting of the Association was held in Washington, D. C., during the week from Dec. 29 to Jan. 3, inclusive. Meetings of several "affiliated societies" were also held at the same place. The meeting was one of the largest in the history of the Association, over 900 members and guests being registered as in attendance. The first general session was held on Monday morning, in St. Matthew's Church. Addresses of welcome were made by Dr. Charles D. Walcott, on behalf of the Washington Academy of Sciences; Hon. H. B. F. MacFarland, on behalf of the District of Columbia; Hon. David J. Hill, on behalf of the National Government; and Dr. Chas. W. Needham, president of Columbian University. The address in reply was made by the president of the Association, Dr. Ira W. Remsen. After the usual routine business the general session adjourned, and meetings of the several sections were held for organization and election of sectional officers in different rooms of Columbian University. The sections and their several chairmen, vice-presidents of the Association, are as follows:

A. Mathematics and Astronomy—George Bruce Halsted, University of Texas, Austin, Texas.
B. Physics—Ernest Fox Nichols, Dartmouth College, Hanover, N. H.
C. Chemistry—Charles Baskerville, University of North Carolina, Chapel Hill, N. C.
D. Mechanical Science and Engineering—Clarence A. Waldo, Purdue University, Lafayette, Ind.
E. Geology and Geography—William Morris Davis, Harvard University, Cambridge, Mass.
F. Zoology—Charles W. Hargitt, Syracuse University, Syracuse, N. Y.
G. Botany—Frederick V. Colville, U. S. Department of Agriculture, Washington, D. C.
H. Anthropology—George A. Dorsey, Field Columbian Museum, Chicago, Ill.
I. Social and Economic Science—H. T. Newcomb, "Railway World," Philadelphia, Pa.
K. Physiology and Experimental Medicine—W. H. Welch, Johns Hopkins University, Baltimore, Md.

On Monday afternoon the addresses of the vice-presidents were delivered before their respective sections. The address of Vice-President Flathie, of Section D, was published in our last issue. In the evening the address of the retiring president, Dr. Asaph Hall, was delivered in St. Matthew's Church. It was a popular address on the subjects of astronomy, its history and probable future development, and the influence of science upon civilization.

On the succeeding days short general sessions were held in the lecture hall of Columbian University, and then the sections met in their respective rooms for the reading and discussion of papers, with the exception of Section K, the new section, which had no papers prepared. The programme of Tuesday, which gave the lists of papers to be presented at each section, showed that the number of papers then ready was as follows: Section A, Mathematics and Astronomy, 20; B, Physics, 25; C, Chemistry, 16; D, Mechanical Science and Engineering, 22; E, Geology and Geography, 38; F, Zoology, 12; G, Botany, 17; H, Anthropology, 23; I, Social and Economic Science, 29. Besides these papers of the sections, the affiliated societies, some of which held joint sessions with the sections, had the following numbers of papers on the programme of the sections: Astronomical and Astrophysical Society of America, meeting with Section A, 33; American Physical Society, with Section B, 23; American Chemical Society, with Section C, 22; Botanical Club of the Association, with Section G, 4; American Anthropological Association, with Section H, 6; American Folk-Lore Society, with Section H, 14; making a total of 304 papers to be read before the sections.

Besides these societies, the following other affiliated societies held meetings: American Forestry Association, American Microscopical Society, American Philosophical Association, American Physiological Society (45 papers listed), American Psychological Association (29 papers), American Society of Naturalists, Association of American Anatomists, Botanical Society of America, Botanists of the Central and Western States, Geological Society of America, National Geographic Society, Naturalists of the Central States, Society of American Bacteriologists, Society for Planet Morphology and Physiology (27 papers), Society for the Promotion of Agricultural Science, Zoologists of the Central and Western States, Sigma Xi Honorary Scientific Society, American Alpine Club, National Association of State Universities.

This list shows that no less than 25 different scientific societies, besides the nine sections of the American Association, all had meetings in Washington in one week, and that 405 papers were presented, besides numerous lectures and addresses. The subjects discussed covered the widest range, from an ordinary problem in physics, such as the thermal conductivity of glass, to a study of the interstellar worlds, as the Motion of 85 Pegasi; from the Composition of Pineapples to the Relics of the Glacial Age; from the Tadpoles of the Green Tree-Toad to the Status of the Subconscious; and from the Fossil Human Remains at Lansing, Kansas, to The Right of the Laborer to His Job. No member in attendance at the meetings could take in a fortieth part of the enormous mass of material presented, or form any idea what fraction of it really pertained to the advancement of science, and what was merely an addition to the bulk of "science falsely so-called." As each member of the Association receives, as part of his return for the $3 he pays for annual dues, the weekly journal, called "Science," which during several months following the meeting will publish some of the papers in full, others in brief abstracts, or "by title," he will be able to obtain some sort of a record of the meeting, and learn whether the particular branch of science in which he is interested has been advanced thereby.

A notable feature of the meeting is the fact that it was the first the Association has ever held in the winter. The adoption by the universities and colleges of "Convocation Week," the week in which the first day of the year is included, as a general holiday week, enabling teachers to attend scientific meetings, is chiefly responsible for the large attendance, but the selection of Wash-

ington as the place of meeting no doubt also contributed to the result.

Another feature of the meeting was the absence of the usual excursions, receptions and other festivities. There were many private receptions given to some of the sections and affiliated societies, several small dinners and "smokers," etc., and some popular lectures. The President of the United States also formally received the members at the White House at 10 o'clock on Saturday morning, the number received being properly limited to 500, to whom cards were issued at the meeting. The absence of the usual social distractions gave the meeting more of a business and scientific character than heretofore.

Section D, Mechanical Science and Engineering, held four sessions. They were well attended as compared with former meetings, and were full of interest. The papers were mostly short, and the discussions were often spirited. The following is a brief statement of titles, together with a few notes on some of the papers:

ELECTRICAL ENGINEERING.—By J. Burkitt Webb.

This was a plea for the presentation and discussion of electrical engineering papers in Section D, instead of in Section B (Physics).

STRESS.—By J. Burkitt Webb.

Attention has often been called to the fact that in mechanics a confusion exists in the use of fundamental terms, which results in many cases from faulty definitions of the quantities employed.

Stress is one of the more recent terms, and a discussion of its meaning may lead to a better understanding of it.

The following distinct points are to be noticed:

(a) It requires two equal and opposite forces to produce a tension, that is, it requires a "couple," and the definition of stress should be consistent therewith and with the following general conceptions:

A definite force applied at any point of a free body produces in one second a definite velocity of translation of its center of gravity. If a "couple" of forces be applied each neutralizes the translation of the other so that the center of gravity is unaffected. The forces of the "couple" have, of course, parallel lines of action whose distance apart is the lever arm of the "couple," and the product of one of the forces by the lever arm is the moment, or torque, of the "couple." A definite torque produces a definite angular velocity, and may be neutralized by an equal and opposite torque so as to leave the body unaffected as to both translation and rotation. It is unscientific to exclude, as some authors do, from their definition of a "couple" the case when the lever arm is zero; the "couple" exists then as much as it ever does.

But besides these kinematic effects, which may or may not be produced, we have the static effect on the body itself, and a body cannot act as the medium for balancing forces or moments without assuming a state of stress, so that a "couple" whose dynamic effect is reduced to zero by reducing to zero its lever arm still causes stress in the body. In a "couple," therefore, the essential property of the forces themselves is neutralized, and the dynamic or static properties of the couple alone remain.

A stress, therefore, is not a force, any more than a "couple" is, although appropriately measured in pounds or similar unit used for forces.

(b) Another point of difference between a stress and a force is that a force is a vector having direction, while a stress has only a line of action. This is the more evident when we consider that changing the algebraic sign of a force reverses its direction, and that to produce one stress, say a tension, we require both the plus and minus forces, thus interfering with the idea of direction. A stress has only a line of action, and changing from plus to minus has nothing to do with direction, but means the change from tension to compression, which corresponds with a reversal of the signs of the forces producing the stress. A plus stress being tension a minus stress is compression with no change in the line of action.

(c) A stress may or may not be considered per unit of area. There is nothing in a stress to make it different from a force in that respect. All forces are actually distributed forces, and all stresses distributed stresses. A stress must be defined as to its inherent nature and not as to a method of measuring it. Sometimes "total stress" is required, and sometimes the "intensity" of the stress, or stress per unit of area, just as we speak of weight per cubic or square foot. That is, we may wish to speak of the tension in a beam or the tension per square inch.

An examination of authors shows the justice of these three points, although I am not aware that they have been distinctly and positively affirmed, and the importance pointed out of making them clear in defining the word stress.

Of course Prof. Webb's definition of stress as a couple could not be allowed to pass unchallenged. One member said it might be unscientific to exclude from the definition of motion the case when the velocity is zero, and to define rest as a specific kind of motion, but he would prefer to continue to use the term rest in its popular sense, as the absence of motion.

A SYSTEMATIC METHOD OF CALCULATING THE DIMENSIONS OF DYNAMO-ELECTRIC MACHINES.—By Carl Kinsley.

This paper showed that the usual method of arriving at the dimensions of parts of electrical machines by calculation can be greatly simplified. In the author's method fewer formulæ are used, and there is much less trial and error calculation. When finally printed the paper will no doubt prove of considerable value to electrical machine designers.

A NEW MECHANICAL AND METALLURGICAL PRODUCT IN COPPER.—By C. A. Waldo.

The new product was shown in two forms. 1, a thin spherical shell, 2½ ins. diameter, with a hole about ⅛-in. diameter in one end, and, 2, a reproduction in thin sheet copper of a common quart whisky bottle. Both samples had neither seam nor weld, and it was stated that they had not been made by electro-deposition. It was stated that seamless shells similar to the one shown, but larger, would be used for floats with automatic valves, replacing those now in use, which are apt to leak at the seam. Prof. Waldo said he was not at liberty to tell how these products were made, and no one in the room was able to solve the mystery.

COMPARATIVE DUCTILITY OF STEEL UNDER GRADUAL AND IMPACT LOADING.—By W. K. Hatt.

This paper described a series of experiments which showed that steel is generally more ductile under impact than under gradual loading, contrary to what is usuallly believed.

CEMENTATION OF ROAD MATERIAL AND PLASTICITY OF CLAYS.—By Alerton Cushman.

This paper described an elaborate research into the causes of cementation of rock used in roads and of the plasticity of different clays. It was found to be due to hygroscopic moisture contained in the rock. When a rock will absorb moisture from ordinary air, as wood will do, then its surface when in contact with another surface of rock of the same kind is converted into a sort of gelatinous substance which becomes a cement. Rocks of this character also form clays of more or less plasticity. The property may be entirely destroyed by heating the clay to redness.

NOTES ON COMPARATIVE DESIGN OF METALLIC ARCH BRIDGES.—By H. S. Jacoby.

This paper was a study of the weights of arch bridges of the two-hinged and three-hinged type, as designed under different specifications. The author showed that the formula for maximum allowable stresses, as given by different authorities, had far greater influence upon the weight of the bridge than the style of the arch has; and that while one formula could make a two-hinged arch heavier than a three-hinged one, another formula would make it lighter. He argued from this that there is great need for revising our formulæ for stresses in bridges.

TOPOGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY.—By H. M. Wilson.

This was a short talk on the recent topographic work, with reference to a map of the United States showing the extent to which this work has been carried.

NOTES ON HYDRO-METALLURGY OF COPPER ORES.—By H. H. Miller.

As the author was not present the paper was read by title only.

On Tuesday evening the section held a session, at which three papers were given with the aid of lantern illustrations. They were:

CONSTRUCTION OF WASHINGTON MONUMENT AND LIBRARY OF CONGRESS.—Bernard R. Green.

A series of photographs showing the reconstruction of the foundation of the monument, which the original builders had designed, apparently without any engineering calculations, and of the completion of the shaft, were accompanied with a very interesting description of the work.

RAPID PRIMARY TRIANGULATION.—By J. F. Hayford.

This was a lecture on the methods now used by the U. S. Coast and Geodetic Survey in its primary triangulation, by which the work is done in a small fraction of the time formerly required, and with greater average accuracy. (See Eng. News, Sept. 4, 1902.)

REACTION VERSUS VELOCITY AS AN ACTIVE AGENT IN REMOVING BARS.—By Lewis M. Haupt.

In this paper Prof. Haupt presented his argument in favor of the single jetty system for channel improvement.

On Wednesday the following papers were presented:

ROAD MATERIAL LABORATORY.—L. W. Page.

This was a description of the laboratory recently established by the Agricultural Department, of its methods of operation and what it hopes to accomplish.

AGRICULTURAL ENGINEERING.—By Elwood Mead.

This paper is published elsewhere in this issue.

THE MECHANICAL PROBLEM OF A NEW ORE-PRODUCING TERRITORY.——By C. A. Waldo.

This paper discussed a recently discovered copper and silver district in the Pan-handle of Oklahoma, where the great problem is what to do with the ore after it is mined. Water, fuel and railroad transportation are all absent. The ore must be concentrated at the mine. There is a choice between the use of electric power generated from a stream over 20 miles distant, which must be impounded to give steady power, and the use of oil engines using Texas oil.

THE METRIC SYSTEM.—By J. Burkitt Webb.

A brief abstract of this paper is the following:

The advocates of the metric system are pushing it more than it is worth. If its opponents would get up a system of their own there would be less chance of its success. Its main advocates are scientific rather than practical men, who make use of the less important parts of the system.

Standards of length lie at the foundation of all our important and accurate manufacturing and engineering work, and an examination of the necessities of this work, in both its theoretical and practical parts, shows that a change to the metrical system would be not only very expensive, but detrimental. It is difficult to estimate the cost of a change from the inch, with its multitudinous ramifications throughout the mechanical world, to metrical units; it would be enormous, and what advantages has metric measure that the inch may not have and much more? As to the size of it, the meter has nothing better to offer, and as to its subdivisions, that into 16 parts is far better than that into ten, except for certain purposes of calculation, and here the right thing to do is not to change to ten, but to so improve calculation by sixteenths as to make it also better than reckoning by tenths.

Sixteen is in many ways a better number than ten, and the change to a system having sixteen as its ratio or root would be such a change as a Chinaman has to make in adopting a European language with its methods of writing and printing and reckoning. A Chinaman might not understand if he were told that his language was inferior, say, to German, any more than a devotee of the meter can see that his idol is at most a poor stick lacking in the proportions needed for common measurement.

THE DRAINAGE PROBLEMS OF IRRIGATION.—By C. G. Elliott.

This was a brief paper describing how some irrigated lands are too much irrigated, and the method of remedying the trouble. Leakage of irrigation canals was also discussed, and to it was attributed the formation of over-moist land in their vicinity.

THE SECOND LAW OF THERMODYNAMICS.—By J. Burkitt Webb.

Various attacks have been made on this Second Law, and in a recent one by Jacob T. Wainwright, of Chicago, of which I shall not attempt a full criticism, there are some peculiarities, two of which may be worthy of remark.

In the first place the writer seems iguorant of, or avoids Rankine's work in this direction, which, to my mind, contains the best statement and proof of the law, in no way touched by his remarks.

The proof is like a nutritious nut; crack the shell, or, failing that, gnaw through it, and you have a perfect kernel, the living germ of the Second Law, from which so much valuable fruit has sprung.

The simplicity of the proof makes the nut hard cracking for some. He holds that evidently heat is of such a simple homogeneous nature that all its differential elements must have the same effect, and further that all the infinitesimal elements of temperature must have equal effects, which last is analogous to the statement that when the camel's back breaks each element of weight has the same effect—the first straw being equal with the last in the actual catastrophe. From this the division of each element of heat by its absolute temperature and the Second Law follow easily.

Secondly, the author's claim that Clausius' proof is faulty (as I pointed out years ago) is correct. Clausius proves the form of his function on the principle that in a reversible cycle all natural working substances must be equally efficient, and then attempts to define the function exactly by discussing the properties of a perfect gas—a theoretical working fluid which doesn't exist in Nature. The proof therefore fails in default of a further investigation showing that the absence of the natural properties which a theoretically perfect gas lacks does not vitiate the result.

A PRESSURE-TUBE ANEMOMETER.—By A. F. Zahn.

The anemometer consists of two rubber tubes ½-in. internal diameter, one of which receives the static pressure, and the other the impact of a moving column of air; each of the tubes leads to a pressure chamber inside of an inverted brass cup, about 6 ins. diameter, the edges of which are sealed by being immersed in a larger cup containing oil. The top of each of these cups is connected to a long beam supported on a knife edge, and the pressures communicated through the cups cause the beam to move. A sensitiveness of a millionth part of an atmosphere is claimed for the instrument.

HYDROGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY.—By H. H. Presley.

This was a description of the work done in obtaining stream flow, etc., during the last year.

FRICTION IN BALL-BEARINGS.—M. J. Golden.

This paper illustrated an apparatus used to determine the friction of ball-bearings of different sizes at different speeds. It was found that at high speeds (about 2,000 revolutions per minute) ball-bearings fail entirely. The results seem to show that for pressures and speeds for which they are suitable ball-bearings, give a loss by friction far less than that of an ordinary bearing with imperfect lubrication, but not much less than that of a finely polished and thoroughly lubricated bearing.

ERRORS IN ANALYSES OF FURNACE GASES SHOWN BY COMPUTATION.—By William Kent.

This paper gave an arithmetical computation, based on the analyses of a certain coal, which proved that the analysis of the gas from the chimney, as reported by the chemist, must necessarily be in error. The analyses of the gas was 8.2% CO_2, 0.6 CO, 7.5 O; 83.7% N, by difference. It was shown that by no conceivable way of burning this coal, smokeless or not, could the nitrogen in the gases be higher than 81%. With such an analysis it is impossible to compute a heat balance in a boiler test with any approach to accuracy.

Three or four years ago an attempt was made by Section D to commit suicide, or rather to obtain sentence of death from the Council of the Association, because, as its members said, it had been shown impracticable to get enough members to attend its meetings to make it worth while to meet at all. The Council, however, refused it assent to the disbanding of the section, and the wisdom of its refusal is now apparent.

A committee of the section has been appointed to take steps which may result in building up the section to be as important a one as the corresponding section in the British Association. There are also many signs of renewed activity in the Association itself, and of its making changes in its organization and methods which will greatly increase its usefulness.

A NEW ORE CLASSIFIER.

In the treatment of gold, copper, lead and certain other ores for the extraction of the mineral, the ore is usually crushed by stamps or rolls and the crushed product is fed to concentrators of different forms (jigs, tables, vanners, etc.), where the particles of metal are separated from the gangue or rock. Before going to the concentrators, however, the crushed material is usually subjected to a sizing process by means of screens or hydraulic classifiers. This is done partly because the concentration is then much more effective, and partly because by this process the slimes or very fine particles are removed, while a large proportion of these would be lost if they remained mixed with the coarser particles. The principle of most of the hydraulic classifiers is that the crushed material is delivered to a tank full of water in which there is an upward current of water, the lighter particles or slimes being carried off with the overflow, while the heavier particles settle to the bottom, whence they are drawn off through discharge openings. These classifiers are usually arranged in sets of three or four, the overflow from one passing to the tank of the next, and so on. The quantity of water delivered is greater than the discharge or spigot can carry off; otherwise there would be no overflow.

In the Klein classifier, the action of the current of water is produced by jets of compressed air entering at the bottom of the tank, thus agitating the body of water and causing the sizing of the material. It enables the same amount of ore to be treated with about 50% of the water ordinarily required, and this is of particular advantage in the treatment of slimes, as the material contains less water when delivered to the concentrators. Another advantage of the process is that it enables a large equipment of sizing screens to be dispensed with, the screens being required only for material coarser than 6 mm. The classifier can treat anything below this size. Some of those now in use make four distinct classifications on material which has passed through a 30-mesh screen and eliminate all slimes at each sizing. The high efficiency of plants using this system is said to be due to the close sizing of the crushed product before it finds its way to the jigs and tables for separation. When the ore contains silver or gold it is sometimes profitable to carry the water finally to a large settling tank, as this water contains the very finest particles in suspension.

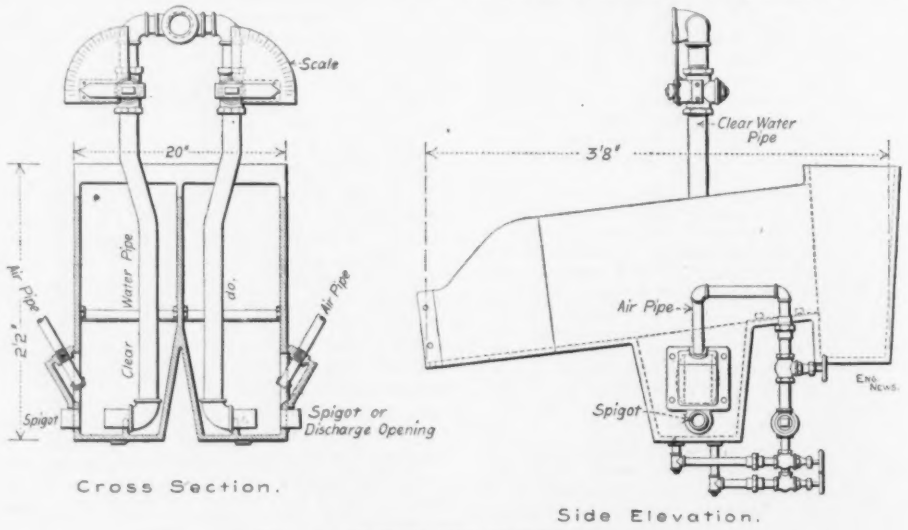


FIG. 1. KLEIN'S ORE CLASSIFIER.
John Klein, Inventor, Desloge, Mo. Allis-Chalmers Co., Makers, Chicago, Ill.

The machine is made in three styles, to suit the size of the material to be treated. Fig. 1 shows the construction of a Klein classifier for material ranging from 6 mm. to 2 mm. in size. The crushed material or pulp from the crushing machinery is delivered at the upper end of the trough and falls into the pocket, where it encounters the upward current of entrained air and is thus thoroughly separated. The coarser or heavier particles fall to the bottom, and are discharged through openings or spigots, leading to the concentrators, while the finer or unclassified particles pass out with the overflow to the next classifier. The classifier shown in Fig. 2 is for material of 3 mm. to 1 mm. in size. This has a deeper pocket in which revolves an agitator driven by bevel gearing, as shown. The third style is for treating material finer than 1 mm., and this is practically identical with the second, Fig. 2, but has no agitator. The separation is made continuously, the finer particles being carried upward with the water and discharged at the overflow, while the coarser and heavier particles are delivered at the spigot opening. The effective work which is done is claimed to be due to the continuous agitation of the water by the air, causing innumerable small air bubbles, which rise rapidly to the top and carry up the finer material and small slime particles. In addition to the compressed air, a small amount of clear water is used, the jet of water performing its work directly opposite the point where the classified material is drawn out. The following description is furnished by the makers.

The principle of the machine is based upon the separation of all slimes and fines from the larger particles and this is accomplished by the constant agitation developed by the introduction of compressed air. The action of the air has a tendency to form small bubbles which continually rise to the surface carrying with them the slimes and fine material, which are carried off in the overflow with a minimum quantity of water. The air is introduced through one or more pipes from the bottom of the classifier transversely against the column of water introduced through a pipe near the bottom of the classifier.

The classification is accomplished entirely by the compressed air, and the water used is only for the purpose of forcing out or discharging the sized product through the discharge openings directly opposite and in line with the water supply pipe. In the classifier for coarse materials, Fig. 1, a spray of compressed air is introduced on an inclination against the water supply to cause an agitation which will prevent the possibility of any fines and slimes being carried through the discharge opening with the classified material by the water supplied. In the classifier for material ranging between 3 mm. and 1 mm., Fig. 2, a mechanical agitator is used to assist in agitation of the pulp in the upper part of the classifier, thereby reducing the quantity of compressed air necessary.

The air should be introduced under a pressure of not less than 30 lbs. and the water at a pressure of not less than 15 lbs. The classifier for coarse materials requires about 50 gallons of water per minute. The classifiers for the finer materials require about 20 cu. ft. per minute. The capacity of the classifiers depends a great deal on the character of the ore, but for ordinary work the coarse classifier can handle about 75 tons per day of 24 hours in each compartment and the classifiers for finer materials can handle about 50 tons in the same time.

These machines have been use for two years at the plant of the Desloge Consolidated Lead Co., Desloge, Mo., which plant has a daily capacity of 600 tons. There are 24 classifiers, six of which are of the type shown in Fig. 1, for coarse material. The other 18 are of the rotary type, Fig. 2, and work in connection with 16 three-compartment Hartz jigs, the classifiers and jigs being at-

tended to by one man. The ore is galena, a lead ore in limestone formation, with a little iron pyrites, and the crushed material is classified to a fineness of ½-mm. Mr. H. D. Quinby, Superintendent, informs us that these machines cost less for operation than other classifiers, give a greater product in the concentrates, and perform the work more quickly.

The Granite Bi-Metallic Consolidated Mining Co. has had eight classifiers (four for coarse and four for fine material) in use for about eight months at its plant at Phillipsburg, Mont., the plant having a capacity of 300 tons per day. They treat a hard quartz, containing silver and a small amount of gold (both associated with iron pyrites), some manganese carrying silver, and a very little lead. Mr. Werner Ziegler, Superintendent, informs us that the Klein classifier gives a greater product in the concentrates than other similar devices, owing to the prompt release of the heavier particles of mineral at the discharge opening. In this respect, the difference in favor of the classifier as compared with revolving screens is very considerable. With trommels or sizing screens used prior to the introduction of the Klein classifier, very little concentrate was obtained in the jig department of the plant, the tendency being to send the fine concentrates into the table department. With the classifier, the fine as well as coarse mineral is discharged early in its progress down the line, resulting in a very increased percentage of concentrates on the jigs, and a correspondingly reduced value of product going to the concentrating tables. This enables the tables to save more of the fine mineral, giving poorer tailings and resulting in a higher saving. Other plants are also using the Klein classifiers.

This machine is the invention of Mr. John Klein, Desloge, Mo., and is being manufactured and introduced by the Allis-Chalmers Co., of Chicago. For drawings and other information we are indebted to both the inventor and the builders.

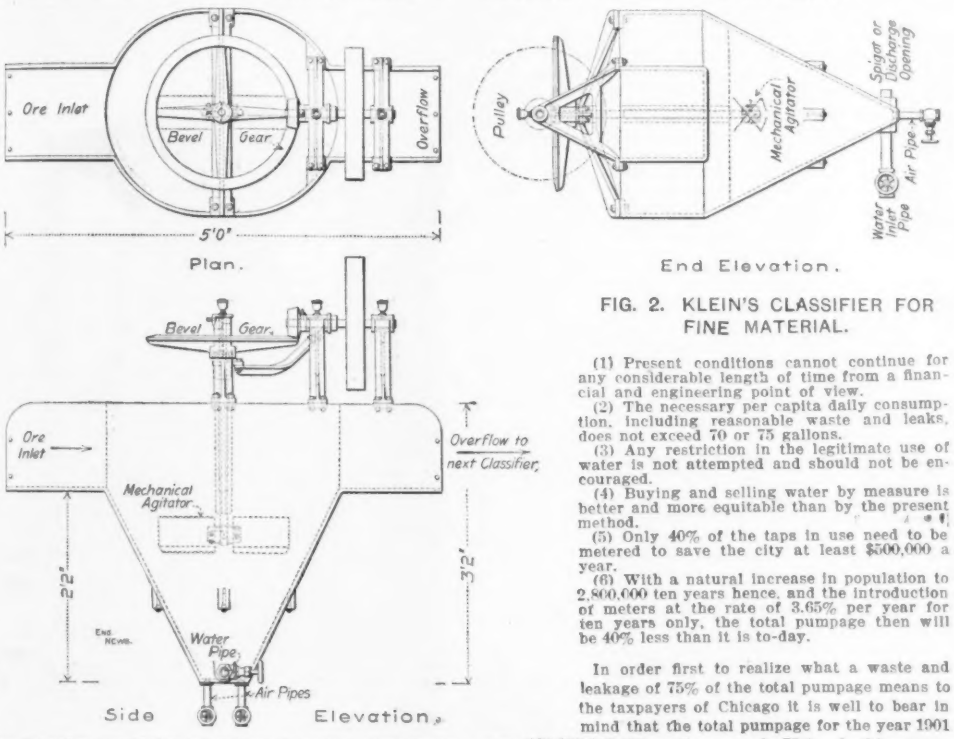


FIG. 2. KLEIN'S CLASSIFIER FOR FINE MATERIAL.

REPORT ON WATER WASTE AND THE METERING OF THE WATER SUPPLY OF CHICAGO.*

Sir: On May 9, 1901, I presented a report showing conclusively that in the city of Chicago there is an enormous waste and leakage of the water pumped at our water-works, exceeding 75% of the total pumpage. The City Council on Oct. 13, 1902, ordered, "That the Commissioner of Public Works be and he is hereby instructed to present to this Council within four weeks a plan for the installation of meters with all necessary information as to cost, etc." In order to fully cover the subject the aforesaid report should be made a part of this present report. In this report I propose to show the following:

(1) Present conditions cannot continue for any considerable length of time from a financial and engineering point of view.

(2) The necessary per capita daily consumption, including reasonable waste and leaks, does not exceed 70 or 75 gallons.

(3) Any restriction in the legitimate use of water is not attempted and should not be encouraged.

(4) Buying and selling water by measure is better and more equitable than by the present method.

(5) Only 40% of the taps in use need to be metered to save the city at least $500,000 a year.

(6) With a natural increase in population to 2,800,000 ten years hence, and the introduction of meters at the rate of 3.65% per year for ten years only, the total pumpage then will be 40% less than it is to-day.

In order first to realize what a waste and leakage of 75% of the total pumpage means to the taxpayers of Chicago it is well to bear in mind that the total pumpage for the year 1901 was 125,298,115,196 gallons, and 75% of this quantity equals 93,973,586,397 gallons. Many of our citizens reason that because we have an inexhaustible supply of water right at our doors water delivered through the pipes should be practically as free and abundant as the air we breathe and as the sunlight from above.

Mr. Rudolph Hering, the eminent Eastern hydraulic engineer, has calculated that in 1901 every million gallons of water pumped at the water-works of Chicago cost, including interest on investment, depreciation, operating expenses and maintenance, $19.50.† (See Proc. Am. Soc. C. E., Vol. XLVI., page 422.) The total cost of the water wasted and leaking away in 1901 is, according to this estimate, therefore $1,832,483. This, in addition to operating expenses, includes all fixed charges. Do the citizens of Chicago receive a reasonable return for this enormous expenditure? If the water thus wasted were necessary to the health and the comfort of our citizens nothing should further be said about this matter. If restriction of the waste and leakage prevents the citizens from obtaining a necessary and lavish supply of water, then emphatically no restriction should be attempted.

Mr. Dexter Brackett, C. E., Engineer of the Massachusetts Metropolitan Water Board, and a recognized authority on water supplies, has compiled a table showing the amount of water used (including waste) in a great number of houses in various cities in the United States and Europe, where the total consumption is metered. Said table is reproduced below.

With an addition of 10% to cover loss in the registration of meters the average consumption per person in these various districts is but 20 gallons, with every person having all the water that can possibly be used. Similar records taken for the purpose of determining the quantity used for trade, manufactory and public purposes show that the actual requirements at present do not exceed 40 gallons per capita for business, mechanical and manufactory purposes, and certainly not more than 5 gallons for public purposes. Making the liberal allowance of 30 gallons per capita for domestic purposes, the total consumption ought not therefore to exceed 75 gallons per capita per day. Mr. John R. Freeman, C. E., another eminent Eastern hydraulic engineer, estimates the necessary quantity of water for all purposes, including reasonable waste, at from 50 to 77 gallons per capita per day for New York. The sanitary conditions in cities where these quantities prove sufficient are as good as or better than the sanitary conditions in cities where the supply of water is several times this amount.

The city of Chicago in 1901 supplied water at the rate of 164.8 gallons per capita per day based on a population of 2,082,695. Buffalo supplies about 275 gallons per capita; Philadelphia, 230 gallons; Pittsburg, 175 gallons; Albany, N. Y., 225 gallons. The health conditions in any one of these cities are not superior to, in fact not so good as those of Chicago. As regards the claim that the waste is necessary for the flushing of sewers, this matter has been investigated by very competent engineers, and it has been found that the leakage and waste in a water system does not flush the sewers. When it is considered that the total pumpage in Chicago corresponds to a rainfall of only 1/192-in. an hour, or ⅛-in. per day, it is readily seen that such is the case. If the leaks and waste are restricted there will be plenty of water and pressure to effectively flush the sewer in a proper manner.

At a liberal estimate not more than 80 gallons per capita per day, including reasonable waste, could possibly have been used in Chicago in 1901, leaving 84 gallons, or about 51%, absolutely lost without doing any useful service. The 51% does not include water which is lavishly used, but only that which is wilfully or negligently permitted to escape. The cost of the 51%, according to the estimate of Mr. Hering, is 51/100 × 125,298,115,196 × $19.50 or $1,246,089. The cost of fuel alone to pump this useless quantity of water in 1901 was 51/100 × $334,560 or $170,625. To this should be added cost in salaries, supplies and maintenance of at least $100,000. Interest on money invested, depreciation, etc., are not included.

The effect of this unnecessary pumping is a great reduction of the pressures all over the city, since the velocity of the water through the pipe system is greatly increased, and the loss of head through friction is proportional to the square of the velocity. This again necessitates larger pipes and consequent large expenditures. Under these conditions, ought not something be done to stop this waste of public funds? In my report of last year I recommended that water meters be installed as a means of reducing this waste. I am fully aware of the unpopularity of such a recommendation in Chicago, as it has also been in every city where the question of meters has first been brought up. But I fail to find anything but satisfaction with the system wherever it has been introduced. I have a number of communications from superintendents of water-works where meters have been generally installed, stating that the general feeling among the citizens is strongly in favor of meters as being the most equitable way of buying and selling water. A system whereby a widow living alone is required to pay as much for her water supply as a family of five or six is manifestly unfair.

It has been argued that the installation of meters will have a tendency to restrict lavish and even legitimate use of water, which, as stated, should under no circumstances be encouraged. Assuming a cottage with an average family of five persons, the lavish and legitimate use per day is as shown not more than 5 × 20 = 100 gallons per day, or 36,500 gallons per year. The cost of this water at a meter rate of 10 cts per 1,000 gallons is $3.65 per year. The present rate is $5.50 for an average one-story cottage without any extra fittings whatsoever. Assuming again a modern residence of three stories, the frontage rate without any extra fittings or garden hose is $14. If we assume twelve persons in the family, the quantity used is about 12 × 20 = 240 gallons per day, or 87,600 gallons per year. This at 10 cts. per 1,000 gallons amounts to $8.76. In every case it can be shown that buying the

*Report made on Nov. 13, 1902, by Mr. John Ericson, City Engineer of Chicago, to Mr. F. W. Blocki, Commissioner of Public Works.

†This includes expenses for distribution.—Ed.

Daily Consumption of Water per Capita in Various Towns, as Determined by Meter Measurement.*

City or town.	No. of houses.	Number Families.	Number Persons.	Consumption, gallons Per family.	Consumption, gallons Per capita.	Remarks.
Boston	31	402	1,461	221.0	59.0	Highest cost apartment houses.
	46	628	2,524	185.0	46.0	First-class apartment houses.
	223	2,204	8,432	123.0	32.0	Moderate class apartment houses.
	39	413	1,844	80.0	16.6	Poorest class apartment houses.
	339	3,647	14,261	139.0	35.6	Average of all apartment houses supplied by meter.
Brookline	40	...	1,699	....	46.1	Boarding houses.
	...	828	4,140	221.5	44.3	Average of all dwellings supplied by meter.
Newton	490	490	2,450	132.5	26.5	All houses supplied with modern plumbing.
	...	619	3,005	.....	6.6	These families have but one faucet each.
	...	278	1,390	34.5	6.9	
Fall River	28	34	170	127.5	25.5	The most expensive houses in the city.
	64	148	740	42.0	8.4	Average class houses; generally, bath and water closet.
	..	...	70,000	.....	12.3	Total domestic consumption.
	..	20,514	90,942	.....	16.8	Whole domestic consumption.
Worcester	..	81	327	80.2	19.9	Woodland St.; best class of houses.
	..	37	187	118.1	23.4	Cedar St.; best class of houses.
	..	93	447	95.0	19.8	Elm St.; houses of moderate cost.
	..	245	1,104	55.1	12.2	Southbridge St.; cheaper houses.
	..	229	809	55.0	15.6	Austin St.; cheaper houses.
Yonkers, N.Y.	...	...	31,000	.....	21.4	.....
London, Eng.	727	...	5,089	.....	18.6	Middle class; average rental $200.
	1,169	...	8,183	.....	25.5	Houses, renting $250 to $600; bath and 2 water closets.

*Transactions Am. Soc. C. E., Vol. XXXIV., p. 189.

water at meter rates will be cheaper than by the present method. In order not to encourage restriction in the use of water a minimum rate of, say, $3 should be established.

As to the effects of reducing the waste by the installation of meters, the almost universal testimony is that up to 50 or 60%, and sometimes even more, is saved by this method. The city of Milwaukee has at the present time about 36,000 meters in use, installed during the last decade. The city engineer informs me that irrespective of increase in population and in the useful consumption of water the pumpage to-day is no more than it was ten years ago. Judge Hillyer, President of the Water Board of Atlanta, Ga. (a city that has been placed more completely under the meter system than any other), in 1898 gave the following results: The conditions of water supply there were difficult. The water, being at times very muddy, had to be filtered. As filtering the water was very expensive, it was decided to place the city under the meter system and avoid filtering the great waste which was believed to exist. The pumpage at that time was 6,000,000 gallons per day and the engines were kept running to their utmost capacity. Even under these circumstances the fire engines had to take water from suction. Such a thing as fighting a fire with the hydrant pressure was unknown. After the meters were put in, the pumpage immediately fell from 6,000,000 gallons to 1,250,000 gallons per day and the pressure increased from 20 lbs. per sq. in. to 60 and 80 lbs.

Similar testimony comes from all cities where meters have been installed. To apply the remedy in Chicago as elsewhere is not, therefore, so much of an engineering proposition as a question of what is the will of the public. In providing for the health and comfort of a community the engineer has to be governed by what the public will do and not by his own theory of what they ought to do. The object of this rather lengthy report is therefore to add, if possible, something to the information of the public on this important question.

From a financial point of view the question presents itself to me as follows: By examining the increase in population in the past the city of Chicago ten years from now will probably have a population of about 2,800,000. The yearly increase in the consumption of water per capita during the last few years would indicate that ten years hence the consumption will be at the rate of at least 200 gallons per capita. If present conditions are allowed to continue, therefore, in 1912 the daily necessary pumpage will be 560,000,000 gallons per day. The present average daily pumping capacity, leaving out a reasonable number of the pumps for reserve, is about 360,000,000 gallons. Assuming the same reserve capacity as at present, the city will therefore have to increase its plant over 37% in the next ten years. The estimated cost of the waterworks plant as it stands to-day is about $32,000,000, of which the pipe system is estimated at about $16,000,000. Leaving the pipe system out of consideration, according to these figures, there will still have to be expended in extensions of the plant during the next ten years $5,920,000 or an average of $592,000 per year. There was expended during the last ten years for tunnels, pumping stations and machinery for pumping $8,017,974 (including judgments for work on tunnels amounting to $1,005,000), or an average of $801,797 per year, exclusive of distribution system.

By platting the information received from annual reports and from superintendents of water-works in various cities of the United States Mr. John R. Freeman, C. E., has established a relation between the percentage of metered services and the consumption per capita that can, I believe, be applied to Chicago, as it indicates the condition correctly as it exists to-day. At any rate it certainly is a good indication of what may be expected, and I have therefore given said diagram herewith. From an examination of this diagram it will be seen that with the increase of taps metered from 0 to 25% the decrease in consumption per capita is very rapid, from 25 to 50% the decrease in consumption is less rapid ,and from 50 to 100% still less. It is about 65 gallons per capita with 50% of taps metered and 55 gallons per capita with 100% of taps metered, or a gain of only 10 gallons per capita for the last 50% of meters placed. Chicago at present has about 3.5% of the taps metered, which corresponds to about 165 gallons per capita on the diagram, the actual consumption being also about 165 gallons. By increasing the number of meters from 3.5% to 40% the consumption, according to this diagram, which (as stated) is based on the actual condition in a great number of cities, should fall from 165 to 70 gallons per capita per day, if the meters are judiciously placed. It has been shown that in the poorer and medium classes of dwellings much less water is wasted than in the better class of dwellings and other places, and as comparatively little is therefore gained after increasing the number of meters over 40% my calculations will be based on this percentage.

Assuming that these meters will be installed during the next ten years, I find that it would be necessary to install about 93,270 meters in that time, or 9,327 per year. The Superintendent of the Water Office, Mr. H. O. Nourse, estimates the taps in use at present at 190,000, and with an increase in population to 2,800,000 in 1912 the proportionate number of taps that year would be 250,000, 40% of which is 100,000; and excluding the 6,730 taps already metered, the total will be 93,270, as stated. If this suggestion should be followed, instead of expending at least $6,000,000 in the next ten years in extensions of the tunnel system and pumping plants in order to increase the average daily pumpage to 560,000,000 gallons, the consumption, instead of increasing, will from year to year decrease irrespective of the natural increase in population, as can be seen by the following table:

Table Showing Increase in Population, Decrease in Pumpage and Consumption of Water, if about 3.65% of the Taps are Metered Each Year for Ten Years.

Year.	Population.	Total taps metered, %	Consumption per capita per day.	Total pumpage, galls.
Present	2,100,000	3.5	165	346,500,000
First	2,170,000	7.15	133	288,610,000
Second	2,240,000	10.80	115	257,600,000
Third	2,310,000	14.45	100	231,000,000
Fourth	2,380,000	18.10	92	218,960,000
Fifth	2,450,000	21.75	87	213,150,000
Sixth	2,520,000	25.40	82	206,640,000
Seventh	2,590,000	29.05	77	199,430,000
Eighth	2,660,000	32.70	75	199,500,000
Ninth	2,730,000	36.35	73	199,290,000
Tenth	2,800,000	40.00	70	196,000,000

According to this table, which is based on the conclusions drawn by eminent engineers after observing facts as they are in other cities to-day, the pumpage, if 9,000 or 10,000 meters are installed each year for ten years, will steadily decrease until, when 40% of the total number of taps in use have been metered, the pumpage will be about 43% less than it is to-day. It can therefore be seen that not one cent would have to be expended in extensions of the pumping plants for many years to come, while if nothing is done to change present conditions an expenditure of an average of at least $600,000 per year will have to be made for tunnels and pumping plants alone.

From information obtained from a number of cities where meters are used I estimate the cost as follows:

Average cost of meters placed inside curb	$16.00
Average cost of repairs per meter per year	.50
Reading meters monthly for manufacturing plants and quarterly for domestic, including computing meter bills	.60

(The city of Cleveland lately paid for ⅝-in. meters, $6.75; ¾-in., $9.45; 1-in., $13.50. Setting meters inside, $3.35; outside curb, between $7 and $8.)

The yearly expense I estimate as follows:

Interest on cost of meters and setting at 3% on $16	$ .48
Depreciation and renewals per meter (life assumed at 20 years)	.80
Maintenance and repairs	.50
Computing meter rates and reading meters	.60
Total	$2.38

By allowing for increase in material and labor say $2.75 per meter per year.

The total expense per year will then be as follows:

Year.	Cost of meters each year, including setting.	Expense: Yearly, all charges.	Expense: Total, per year.
First	$149,232	$25,649.25	$174,881.25
Second	149,232	51,298.50	200,530.50
Third	149,232	76,947.75	226,179.75
Fourth	149,232	102,597.00	251,829.00
Fifth	149,232	128,246.25	277,478.25
Sixth	149,232	153,895.50	303,127.50
Seventh	149,232	179,544.75	328,776.75
Eighth	149,232	205,194.00	354,426.00
Ninth	149,232	230,843.25	380,075.25
Tenth	149,232	256,492.50	405,724.50

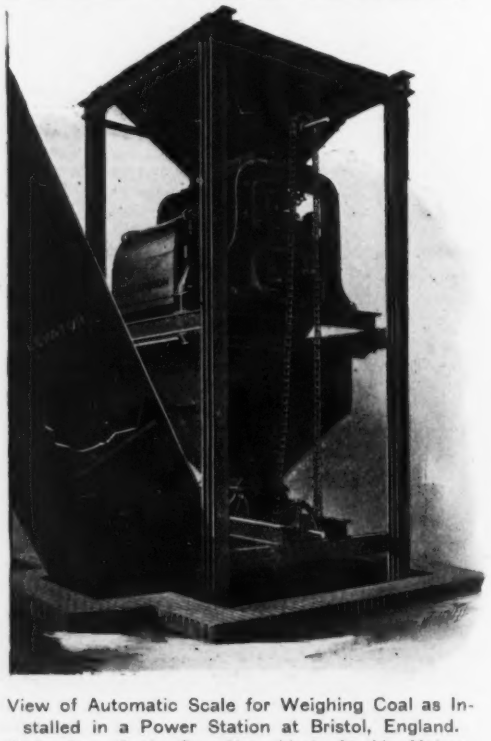
By placing meters outside the curb and using vitrified sewer pipes for setting, which may be preferable to placing the meters in cellars, the cost, including all charges, is estimated at $216,655 the first year, increasing gradually until it reaches the sum of $447,696 the tenth year. After the tenth year, when 40% of the taps shall have been metered, the annual expense, consisting of interest, depreciation, repairs, renewals, reading of meters, computing meter rates, etc., will not exceed $257,000 if meters are placed inside curb in cellars, or $280,000 if placed outside the curb. The saving over present conditions, if they were allowed to exist until ten years hence, in the cost of fuel and operation alone, assuming the cost per million gallons per foot head to remain as at present, would be at least $450,000 per year. Add to this the cost of improvements and additions necessary each year, the saving ten years hence would be at the rate of at least $900,000 or $1,000,000 per year, irrespective of interest on investment. In addition, the city would have a much more satisfactory service.

While the introduction of meters on a larger scale than at present can commence immediately, I would strongly recommend that a systematic survey of the leak and waste situation in the city be made without delay, in order to determine the relative losses in various districts. This can be done most effectively and cheaply by the use of an instrument called the pitometer, developed by Mr. Edward S. Cole, M. E., of Chicago. By means of this instrument the quantity of water supplied to any district can be readily determined and leaks and waste traced and checked. This work can be done at a very nominal cost, and an appropriation made for this purpose will, I am sure, not only pay for itself many times over, but it will greatly aid the department in solving some of the puzzling problems in furnishing outlying districts with an adequate supply of water.

AN AUTOMATIC WEIGHING HOPPER SCALE.

The accompanying cut illustrates an automatic scale which is being put on the American market by the Richardson Scale Co., of 15 Park Row, New York city. The cut is made from a photograph taken in a large power station at Bristol, England, where the scale is used to check the coal as it enters the plant. The working of the machine may be described as follows:

The material to be weighed is supplied from a hopper or bin above the scale, and is admitted into the weigh-hopper by means of a swinging cut-off, which, at the beginning of the operation, is open. When the charge is nearly completed, the cut-off, actuated by the increased weight of the weigh-hopper, partially closes and reduces the stream of material to a mere dribble. When an exact balance is reached the cut-off completely closes, stopping the flow, and in doing so throws up a lever, which sets in motion the mechanism which opens the bottom of the hopper, and, as soon as the charge has been dumped, closes it and locks it again. In closing the bottom of the hopper the dumping mechanism again strikes the lever, throwing it down, and thereby causing the cut-off to open and allow a new charge to flow into the weigh-hopper. The movement is a very simple one, the only power required being the momentum of the falling material.



View of Automatic Scale for Weighing Coal as Installed in a Power Station at Bristol, England. Richardson Scale Co., New York, N. Y., Makers.

The special advantages which are claimed for the machine are: (1) An absolute balance of every weighing. The drip or column of material which is in the air at the moment the feed is automatically cut off is compensated for in the Richardson scale by a novel contrivance which works automatically, and without the manipulation of any of the working parts. (2) A long equal-armed beam, swinging entirely free and independent of any of the working parts of the machine, thus insuring frictionless movement. (3) A weigh-hopper and closed weight-box entirely free from the guides or stay rods, which in some other makes are necessary to prevent the rocking and shake of the hopper which takes place during the discharge of the machine and causes friction and unnecessary wear on the knife edges, and so invalidates the accuracy of the weighings. The hopper on the Richardson scale delivers its discharge without any rocking or vibration on the delicate knife edges. (4) The scales occupy less room in height than any other machines of similar capacities.

The scales are adapted to the weighing of many different materials, and are made in many sizes, with hopper capacities running from a few ounces to six tons.

SOME REQUIREMENTS OF MACHINE TOOL OPERATION; WITH SPECIAL REFERENCE TO THE MOTOR DRIVE.*

By Charles Day.†

In the machine shop of a short time since (in fact in many of to-day) no one could be found who knew anything of the cutting speeds which different brands of tool steel will permit, the size of cuts that the various machines will pull, the feeds that are or should be used, and so on. In a shop of this character one usually finds the tool steel and machines ordered through a purchasing department by men who do not understand the first thing about the requirements to be fulfilled or the relative merits of different machines. It has never occurred to such men to analyze the conditions, and what seems to be economy to them in many cases represents a most extravagant policy.

The only way the relative data can be quickly grasped is by presenting them graphically to the mind; the chart,

Fig. 1. Diagram Showing the Composition of a Selling-Price.

Fig. 1, may be taken as the distribution of cost of the finished product of an ordinary shop. In this way the relative importance of each factor can be realized at a glance and the advisability of an expenditure of energy or money in any direction can be readily determined. My remarks will relate to shops doing a general class of work, as it is much easier to arrive at a high standard where parts are duplicated in large numbers.

We will suppose the castings have been received in the shop and the method of machining determined upon. A certain amount of metal has to be removed and a definite finish is required, our object being to accomplish this result in the least possible time, or rather at the least expense.

The tool steel is the keynote to the situation, and a complete knowledge of its characteristics and possibilities form the starting point for all further work. Carbon steel will give a finer finish on steel than the air-hardening variety, and for form cutters is still largely used. Where heavy roughing cuts are possible, air-hardening steel has unquestionably replaced it; and, in fact, the recent developments in the processes of hardening have been the direct means of revolutionizing old methods of machine tool design and so-called shop practice.

The influence of the Taylor-White process has been so revolutionary in character that I feel justified in dwelling upon it for a few moments. The underlying principle of this discovery is clearly shown on the accompanying curve, Fig. 2, which is plotted from cutting speeds and temperatures. It will be seen that this curve rises from the zero point until 1,550° are reached, when the cutting values suddenly fall off; this represented the full extent of our knowledge when the experiments at Bethlehem were undertaken. The most interesting and valuable fact, that these values again increase if the hardening temperature is carried beyond the "breaking down point," was the result of work just referred to, and the superiority of steel treated in this way as compared with Sheffield Mushet—which was probably equal to any air-hardening steel on the market at that time, may be expressed as follows:

	Mushet.	Taylor-White.
10 C. steel	1.0	2.2
80 C. steel	1.0	3.5
Cast Iron	1.0	1.3

These figures are the result of a series of tests conducted by the Franklin Institute and represent the facts as nearly as they could be determined. There are now a number of makes of steel in the market treated along the lines explained above, which give equally as good results.

An exact knowledge of the cutting speeds of which these tools will permit when machining different materials, and the power to pull various cuts under all conditions, are absolutely essential if we wish to properly design machine tools, or use them to their full capabilities in actual service. The value of this information is now being realized by several of the machine tool builders, and the results are already being felt in the shop in the form of much more efficient machine tools.

In all discussions of this kind we must ever keep before us the fact that some work will permit of heavy cuts and coarse feeds and some will not, but even in the latter cases there are many ways open to cheapen production. Where the work is light and the operations of but short duration it is very essential that the changes in speed should be obtained with the least loss of time; in other words, "ease of handling" is a most important factor.

I think we are now in a position to consider the method of driving machine tools, the requirements to be met being the following: A machine having been designed for a given duty, its maximum and minimum speeds are limited by the character of the work it will do; the number of speeds is determined by the character of the metal machined and the uniformity of the tool steel and the power required is fixed by the most severe conditions it must meet.

For the average machine tool we do not think present conditions demand a closer speed regulation than 10%, as no good means has yet been reached for determining the character of the metal, and in the average shop little is understood about the relations existing between feed, speed and depth of cut for various materials.

For certain classes of work slide rules based upon empirical formulas seem to be the only solution to the problem. By means of these most ingenious rules it becomes possible to instruct the workmen how to do the work to insure maximum efficiency, the feeds, speeds and cuts all being dictated indirectly by the positions of the various handles and gears controlling these factors.

The cutting speed for steel is determined by the tensile strength and elongation, while for cast iron the problem is still more complex. The hardness is not only affected by the chemical composition, but the method of cooling and size of the casting, so that we seldom find two castings that will permit of machining at the same speed. It is possible, however, by careful observation and experiment, to ascertain approximately for a given shop the cutting speeds of which various jobs will permit, so it is absolutely essential to have some good means of determining it. It is impossible to judge the speed by eye, even where a man works on the same tool continuously; nor will the character of the chip when cutting cast iron indicate the proper speed. As a means of remedying this difficulty charts may be used which enable the men to ascertain the cutting speed from a knowledge of the diameter of the work and location of belt and gears, but a much better scheme than the charts is the use of tables designating the spindle speed for each point of the controller or position of the belt, as feeds are frequently enumerated on lathes, etc.

The most characteristic and valuable features of the electrical driving systems, which we will now consider, are the elimination of complication and physical effort in handling the machines, and the direct advantage resulting from this cause may be very far-reaching.

The inefficiency of the belt and step cones, as a means of machine tool driving, even when installed in such a way as to permit of good crane service, is too well understood to demand much consideration here. It is not a question of does it fulfill present conditions, but will it meet the new requirements resulting from the advance in tool steel and our better knowledge on the subject? It certainly will not. The motor is an equally poor investment if, after its introduction, the shop is run along the same old lines, and for this reason an understanding of its possibilities is most essential; I refer, of course, to the motor on individual tools.

The constant speed motor, particularly of the alternating type, is so simple in character that we naturally turn to it as a possible solution to the problem. It lacks, however, the two great essentials, ease of handling and

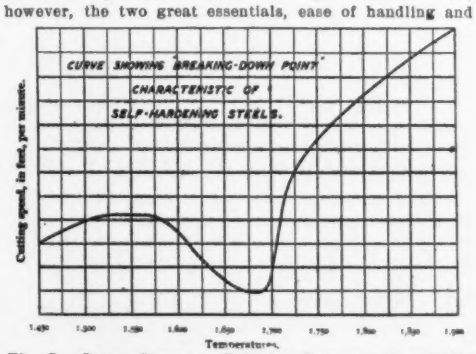


Fig. 2. Curve Showing Relation Between Hardening Temperature and Cutting Speeds of Tool Steels.

speed regulation, and all attempts to supply these shortcomings by mechanical means have so far proved unsatisfactory.

The induction motor is a source of power the same as the line shaft, and the principal advantages resulting from its use are clear overhead room, independent location and possibly a saving in power. The motor is handled from the head stock, and as a result the ease of handling is far inferior to the old belt and shifting pole. The heavy double belt of such short centers must be tightened to such an extent that much time is lost in shifting, and in many instances it would not pay to do so. When the operator is working at a distance from the head stock on a job where the tool is liable to dig in and cause trouble, it becomes necessary to have a helper at the switch to shut down the motor upon signal from the machinist, the inefficiency of such an arrangement being self-evident.

The variable speed counter shaft would seem to be a natural solution; however all such devices that depend upon power transmission through friction, are unsatisfactory for general adoption in the shop, and in most cases the method of handling is not comparable with the multi-voltage system that I will describe later .

Having made up our minds that ease of handling and close speed regulation cannot be efficiently obtained with the constant speed motor, we will direct our attention to the variable speed type.

I shall not attempt to fully discuss the relative merits of the various systems, as it would be essential to go into details involving a paper equally as long as the present one. Fig. 3 shows the schemes of voltages adopted by the principal manufacturers of multiple-voltage ap-

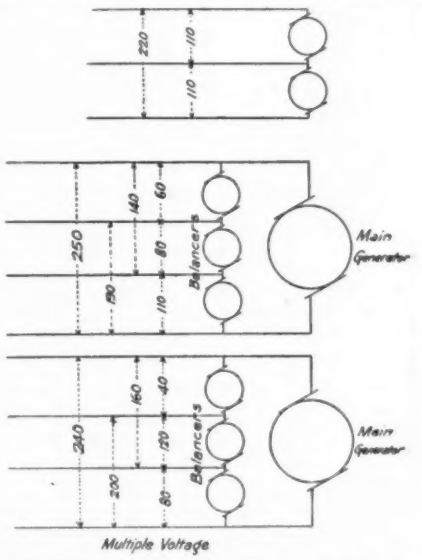


Fig. 3. Diagram Illustrating Voltage of Circuits in Multiple-Wire Systems of Operating Electric Motors.

paratus, one sketch showing a three-wire system and the other two four-wire systems, the voltages being arranged in geometrical and arithmetical progression respectively. In the first instance but two voltages are used, while in the latter cases six are possible. Intermediate speeds are obtained by inserting resistance in the field, 100% variation being necessary in the three-wire system, as compared with 30% in the four-wire. In either case the horse-power that the motor can develop satisfactorily is directly proportional to the voltage.

The satisfactory operation of these systems can only be ascertained after experience with the apparatus in the shop, so we can readily see how many considerations must be looked into before a final decision as to their relative merits can be reached. In a desirable system, standard motors should be utilized, the controller operated by a single handle, and the entire range of speeds passed over while the work continues.

The range of motor speeds is a most important factor, as the first cost of the motor, the cost of the installation and the efficiency of the outfit are all dependent upon it. It is impossible to lay down any fixed rules to base our discussion on, as each machine is a different problem, and must be treated as such. For general machine shop work a range of 4 to 1 to 6 to 1 adapts itself to all conditions fairly well, but in every case where old tools are being equipped we must be satisfied with a compromise.

I have frequently said that we have endeavored to show by exact figures when it pays to use individual motors, but such reasoning has always proven most unsatisfactory. If we cannot accurately figure beforehand what economy will result from the use of the motor, it may at least be of interest to investigate the records of shops who have made such installations. We must, however, be very careful not to draw too hasty conclusions as to the merits of the apparatus from such investigations, as the equipment is utterly useless without the management and organization behind it.

In the shops of the Link Belt Engineering Co., an accurate record, extending over five years, gives the pound cost of machining, and the reduction in this figure during this period gives a more accurate gage of the economy effected than any other method. These figures were compiled by a disinterested party, and after taking into account every detail which might in any way introduce an error, and allowing the men a decrease of 10% in time, with the same wages per week, a clear saving of 30% on the entire labor bill was shown. It is needless to say that this saving is vastly in excess of the interest and depreciation on the entire expenditure necessary to bring about the result.

*Condensed from a paper read before the New York Electrical Society Dec. 17, 1902.

†Of the engineering firm of Dodge & Day, Nicetown, Pa.

THE PROPOSED NEW TERMINALS OF THE NEW YORK CENTRAL RAILROAD AT NEW YORK CITY.

The proposed terminal improvements of the New York Central & Hudson River R. R., at New York city, which were referred to briefly in our last issue, are graphically illustrated by the bird's-eye sketch and general profile which are presented on this page. These improvements are those suggested by the railway company with certain modifications demanded by the special committee of the Board of Estimate and Apportionment, whose report of Dec. 22, 1902, has just been adopted by the Board, but has not yet been formally agreed to by the railway company. While, therefore, the plans shown have not the sanction of formal mutual agreement on the part of the railway company and the city, it is not likely that this agreement will be long delayed. Their description is, therefore, a fairly certain statement of the work which is to be done within the next five years to improve this very important and long neglected terminal.

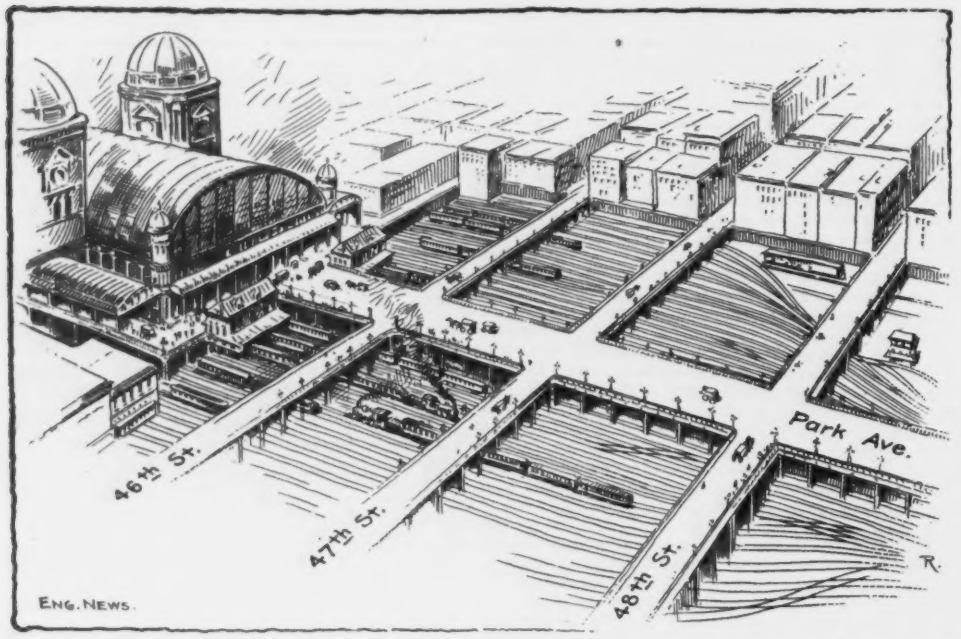


FIG. 1. SKETCH SHOWING PROPOSED NEW TERMINAL TRACKS AND ELEVATED STREETS FOR THE NEW YORK CENTRAL & HUDSON RIVER R. R., AT NEW YORK CITY.

Beginning at 57th St., the present tracks running south along Park Ave. are to be increased in number by three tracks on each side, and beginning at the same point all tracks will be depressed so as to go under the present summit, Fig. 2, and abolish the present grade of 1.25%, which reaches its highest point at 49th St. At the station this depression will be 7 ft. below the floor elevation of the waiting-room and concourse and will be reached by ramps from this elevation. Beginning at about 49th St. the main tracks on Park Ave. will begin to spread out into a system of yard and station tracks, as shown by Fig. 1. Twenty of these tracks will pass into the train shed to the head house, and the others will terminate at 45th St. So much for the new track arrangement.

The present station will be modified as follows: The present waiting-room will be lengthened so as to extend nearly the whole width of the 42d St. front of the head house, and the concourse onto which the waiting-room opens at the rear will be widened 20 ft. The train shed will be extended in width by a glazed roof to cover the tracks now contained in the annex adjacent to Depew Ave., and thus include all station tracks under one roof. Underneath the concourse there will be a corridor connecting with the Rapid Transit subway station. Vehicle traffic will enter the station on the west side at 45th St., and will be distributed on an elevated driveway extending entirely around the main train shed. All vehicle traffic will thus be removed from the 42d St. end of the station. To connect with this driveway at the rear end of the train shed Park Ave. will be extended south on elevated structure, and elevated structures at the same level will carry 46th, 47th and 48th streets across the yard tracks, as shown by Fig. 1, which we have redrawn from a sketch published in the New York "World."

The plan also provides for a double-track tunnel connection from the main line tracks on Park Ave. to the Rapid Transit subway. The profile of these tunnel tracks is shown by Fig. 2.

The foregoing describes briefly the plans of the proposed improvement as it is approved by the Board of Estimate and Apportionment. The following summary of the conclusions of the Board's report gives further details of the plan as follows:

1. That the vault spaces under sidewalks about the station and in Lexington Ave. be not granted in this connection.

2. That the grades shown and the general plans of the railroad companies, both for Park Ave., the Grand Central Station, and for the elimination of the grade crossings at Morris Heights, Fordham Heights and High Bridge, and its plan for the elimination of grade crossings in the vicinity of Kingsbridge, including Kingsbridge Road, East 230th St., Broadway, Corlear St., Tibbet Ave., West 230th St., and West 227th St., under the provisions of Chapter 516 of the laws of 1901, be generally approved; except

3. That Park Avenue be continued by a 60-ft. viaduct from 49th St. to 45th St.

4. That the railroad companies engage to prepare at once plans for the elimination of their only remaining grade crossings in the Borough of the Bronx, to wit, on the Port Morris branch of the Harlem road, and when said plans are approved by the city, to execute the same.

5. That if the execution of any of the aforesaid plans create any legal liability on the part of the city or the railroad companies to any property owners, the railroad companies shall pay the same and save the city harmless therefrom.

6. That it be recommended to the Rapid Transit Commission to consider favorably plans for the connection of the subway at 42d St. with these railroad lines, and also for the connection of the 42d subway station with the Grand Central Station, and that the railroad companies ask for these connections of such commission.

7. That the railroad companies pay the city an annual rental of $25,000 for the use of the sub-surface of streets shown on their plans, south of 57th St. and Park Ave., except as to vault privileges as provided in the first recommendation; assume all the expense of building the bridges and viaducts from 45th to 56th streets, inclusive, except for the additional width of the 45th St. viaduct, and less the sum of $600,000, determined as the cost to the city of acquiring and building equivalent street space; contribute the land for the city to build the Park Ave. viaduct provided for in the third recommendation; and in all other respects bear the costs and charges involved, and as stated in their proposition of Dec. 3, 1902.

8. That upon such bridges and viaducts may be erected such signaling apparatus as may be necessary to the safe operation of the railroads, and which cannot be placed or used in the yard or station below, the plans for which shall be first approved by the Mayor and the President of the Borough of Manhattan.

9. That the entire action of the city herein is conditioned upon the railroad companies procuring, assenting to and aiding the city to procure all legislation necessary to carry these plans and propositions into effect in their entirety and without modification (except such as the city voluntarily accepts), and which legislation shall also permit and require the change of motive power from steam to electricity or some other motive power not involving combustion in cars or motors by all the railroads now or at any time hereafter using the tunnel in Park or Fourth Avenue, which permission and requirement shall contain, however, a proviso that in an emergency arising from a breakdown of the motive power used, through trains only may be temporarily operated by steam, the emergency in each case to be determined by the Mayor of the city.

10. That the changes herein involved shall be commenced within 30 days after such legislation is had, prosecuted diligently and finally completed within five years.

11. That no power house (except stations for the transformation of electric current) shall be placed on Manhattan Island more than two blocks from the water front, except with the consent of the Board of Estimate and Apportionment, and that the location of all such power houses shall be first approved by the Board of Estimate and Apportionment.

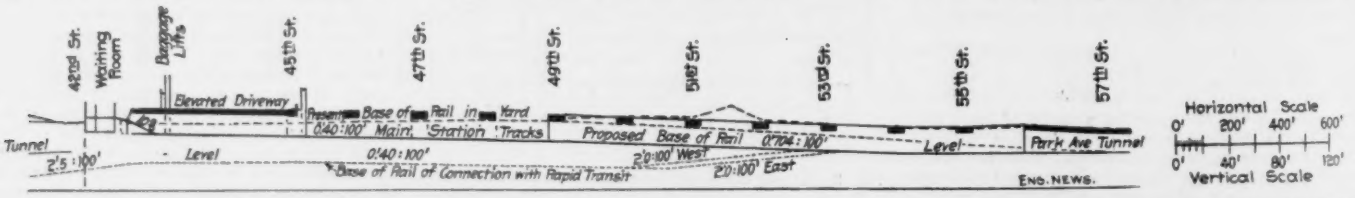


FIG. 2. PROFILE OF PRESENT AND PROPOSED TRACKS OF NEW YORK CENTRAL & HUDSON RIVER R. R., ENTERING THE GRAND CENTRAL STATION, NEW YORK CITY.

THAT LAKE SUPERIOR COPPER ORES grow leaner with depth seems an irresistible conclusion from the poor ground opened up by Tamarack shaft No. 5 (a mile deep). The deep shafts No. 3 and No. 4 of the same company have also shown similar leanness of the ore bed.

RAILWAY CONSTRUCTION IN THE UNITED STATES during 1902 exceeded that of 1901, and, in fact, exceeded that of any year within the past decade. This construction includes only these lines on which track has actually been laid. The "Railway Age" gives the construction for 1902 as 5,549 miles built in 44 States and Territories by 349 lines; this is its highest record since 1890. The "Railroad Gazette" gives 6,026 miles built in 43 States and Territories by 293 companies; this is its highest record since 1888. This latter paper also reports 342 miles built by 13 companies in Canada, and 393 miles built by 11 companies in Mexico. In the United States, the greatest amount of work has been in the southwest, as shown by the following figures, but it will be noted that there is considerable discrepancy between the two records:

	"Ry. Age."	"R. R. Gazette."
Indian Territory	541 miles.	563 miles.
Oklahoma	532 "	570 "
Texas	480 "	496 "
New Mexico	358 "	280 "
Arkansas	308 "	371 "
Total	2,219 miles.	2,080 miles.

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